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Effects of extended exposure to the truly random control procedure

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EFFECTS OF EXTENDED EXPOSURE TO THE TRULY RANDOM CONTROL PROCEDURE

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Abstract

In Experiment 1 one group of albino rats was exposed to only a brief truly random sequence of tone CS and shock US. The remaining groups were exposed to similar sequences which were 3, 6, or 12 times as long. Conditioning to the CS tone was measured using a conditioned suppression procedure. Strong conditioning was found in the group receiving the briefest treatment. Intermediate levels of conditioning were demonstrated for those groups exposed to intermediate lengths of sequences.

The purpose of Experiment 2 was to determine which event or events in the truly random control were responsible for the weakening of conditioning found after extended exposure to truly random training. The findings suggest that if chance pairings are allowed, then both CSs and USs alone must occur in order for conditioning to be weakened significantly. The occurrence of either CSs or USs alone in addition to chance pairings did not appear to be sufficient to weaken conditioning. In addition, loss of conditioning (forgetting) was demonstrated when animals received only extended exposure to apparatus cues after initial truly random training.

Experiment 3 was conducted to establish whether animals receiving extended exposure to apparatus cues after initial truly random training would recondition. The results show that such conditioning can be demonstrated.

The truly random control (Rescorla, 1967) has been widely used in recent years as a proper control procedure to assess the effects of more conventional Pavlovian conditioning procedures. As is now well known, the truly random procedure consists of introducing CSs and USs randomly and independently of each other so that US presentations are equally likely in CS presence and absence. In such a procedure CS presence provides no more information about the time of the US occurrence than does CS absence, and for this reason the CS is expected to remain relatively neutral (Rescorla, 1967).

Despite the widespread use of the truly random control, several investigators have questioned its neutrality. These investigators have discovered conditions in which subjects exposed to the procedure later behave as if they had been exposed to forward conditioning procedures instead (Benedict and Ayres, 1972; Kremer, 1971; Kremer and Kamin, 1971; Quinsey, 1971).

One important determinant of conditioning in the truly random control appears to be the location of chance pairings (Benedict and Ayres, 1972). Benedict and Ayres (1972) found that conditioning was more likely to occur when chance CS-US pairings happened to occur early in the truly random sequence before many non-pairings were presented.

The possibility exists that a subject exposed to the truly random control containing early chance pairings might initially detect a CS-US contingency and condition accordingly.

However, after extended exposure to the truly random control, the subject would have a greater opportunity to learn that the CS did not provide reliable information about US onsets; and therefore its conditioning might extinguish. These considerations suggest that conditioning produced by brief exposure to the truly random control might be extinguished by extending the duration of the exposure.

Direct evidence on this point was presented by Rescorla (1972). He manipulated the amount of exposure to the truly random control and found evidence for conditioning in his briefest treatment (2 hrs) but not after his longest treatment (12 hrs).

While Rescorla's data suggest that treatment duration is an important determinant of conditioning in the truly random control, the conditioning produced by his briefest treatment was very weak, and the CSs and USs were widely distributed in time so that CS-US temporal contiguity was minimal. In contrast, the conditioning produced by the procedures used in Benedict and Ayres' (1972) study was very strong, and CS and US presentations were relatively massed. It seems likely that these factors of strong conditioning and close CS-US temporal contiguity could mitigate or even eliminate the effects of extended training.

The purpose of the present experiment was to assess the effects of extended exposure to a truly random procedure that produced strong conditioning in the experiment of Benedict and Ayres (1972).

Experiment 1

Method

Subjects

Thirty albino rats were used as subjects. Each S was 90 days old on arrival from the Holtzman Company, Madison, Wisconsin. The animals were individually housed and fed ad-lib for five days. Then, over a five-day period, they were fed 3-5 gms. daily to bring them down to 80% of their ad-lib body weight. They were maintained at this weight for the duration of the experiment. Throughout experimentation Ss were weighed before and fed approximately 10 minutes after each session.

Apparatus

Six standard Gerbrands operant chambers with left-side dipper feeders (model B) were used. Each chamber was housed separately in a ventilated 0.61m cube made of 12.7mm plywood lined with accoustical tile. The floor of the cube was covered with a sheet of Masonite. A continuous white noise of 84dB. was presented through a speaker mounted on the lid of each of the operant chambers. The CS was the onset of a 1,000-HZ 84dB. tone produced by a General Radio tone generator. The CS tone was presented through the same speaker as the continuous white noise used for background masking, but never simultaneously with the white noise.

The USs were scrambled 2mA. shocks provided by six Grason-Stadler shock sources (model E 1064GS and 700).

Bar-pressing produced a reinforcement consisting of a 4-sec. presentation of a 0.1-cc dipper cup containing 32% (W/W) sucrose solution. Standard programming equipment housed in an adjoining room controlled stimulus and response contingencies.

Procedure

Preliminary Training. Preliminary bar-press training consisted of three 1,000 sec. sessions under a VI-1 min. reinforcement schedule (Fleshler and Hoffman, 1962). Following VI training, three habituation or pretest sessions were conducted. During these sessions two 1-min. CSs were presented during Minutes 8 and 14, while the Ss bar-pressed on the VI schedule.

Truly Random Training. Truly random training started on the day following habituation and, for Groups 2, 6, 12, and 36, lasted for either 2, 6, 12, or 36 days. During this training, the Ss were blocked from bar-pressing by the insertion of four-walled Masonite inserts with 1.9 cm vertical black and white stripes. Each group (N=6) received sequences of 20-sec. CSs and 1-sec. USs distributed randomly with two restrictions:

1) At least 1 second had to separate consecutive CSs and USs.

2) The total number of pairings over any two sessions had to be equal to the number expected by chance.

The four groups were presented the following sequential CS-US presentations: Group 2 was exposed to the .66-.10-.07 truly random sequence used by Benedict and Ayres (1972). These numbers denote respectively the probabilities of CSs, USs, and chance pairings in the sequences. Multiplied by 100, they denote the absolute number of CSs, USs, and chance pairings which occurred. This sequence produced excitatory conditioning in the previous work. Group 6 was exposed to the same sequence, then to two additional similar but independently generated sequences. Group 12 was exposed to the same truly random sequence as Group 2, then to five additional similar but independently generated random sequences. Group 36 was exposed to the random sequences of Group 12 for three consecutive times. Thus, Groups 2, 6, 12, and 36 received an exposure to the .66-.10-.07 random sequence that was 1, 3, 6, and 18 times as long as the exposure used by Benedict and Ayres (1972). Two 1,000 sec. sessions were required to administer each sequence; thus, Groups 2,6,12, and 36 received a total of 2,6,12, and 36 sessions of truly random training.

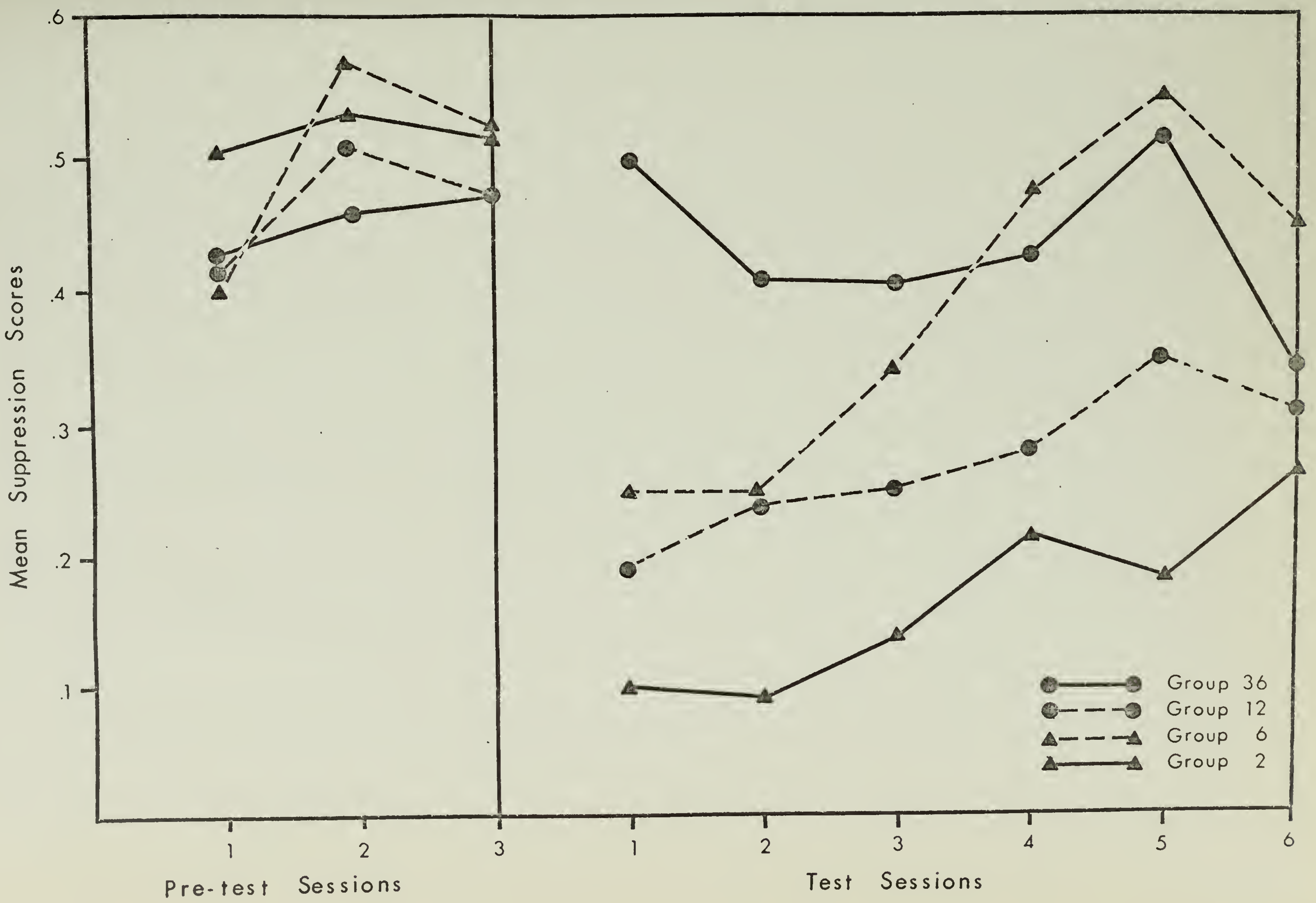
Base Line Recovery. Following truly random training, the subjects were given one day of operant recovery. The procedure consisted of placing the subjects into the operant chambers, and allowing them to bar-press on the VI-1 min. schedule of reinforcement used in preliminary training. Individual Ss were removed when the total number of responses per 1,000 sec. period was 60% of their total in the last 1,000 sec. pretest session.

Testing. Testing began on the day following base line recovery and consisted of six sessions in which conditioned suppression to the tone CS was measured. During each session a 1-min. CS was presented in Minute 8 while subjects bar-pressed for sucrose. During this testing, shock was never administered.

All sessions in this experiment were 1,000 sec. long except for the recovery session.

Treatment of Data. In all tests for suppression, the basic datum was the Annau and Kamin (1961) suppression ratio, defined as D/(B + D); D indicates the responses that occurred during the 1-min. CS; B indicates the responses that occurred in the 1-min. before the CS. The suppression ratio varies from 0 (indicating maximum suppression) through .50 (indicating no effect) to 1.0 (no responses before CS but some during it). If a subject did not respond in the presence or absence of the CS on a given trial, a suppression ratio score was assigned based on the average of his two nearest trials.

Fig. 1 Effects of four different levels of extended exposure to the truly random control procedures on conditioned suppression of bar pressing in Experiment 1.


Mean Suppression Scores
.6
.5
.4
.3
.2
.1
1
2
3
1
2
3
4
5
6
Pre-test Sessions
Test Sessions
Group 36
Group 12
Group 6
Group 2

Results

Figure 1 shows the mean suppression ratios for both pretest and test sessions. In this experiment the four groups did not differ in terms of either their pretest suppression ratios or their pre-CS response rates in testing (shown in Appendices A and C). Thus differences in suppression among groups during test sessions were not confounded with either pretest differences or differences in base line response rates.

Figure 1 also shows that after truly random training, Group 2 strongly suppressed to the CS, while Group 36 did not suppress at all. Group 6 and Group 12 both suppressed, but at levels intermediate between Groups 2 and 36.

Across test trials, Groups 2, 6, and 12 show an increase in their suppression scores, suggesting an extinction of conditioning as a result of the CS alone test procedure.

A comprehensive analysis of variance was performed on the suppression ratios for the six test sessions. Significant differences were found between groups ($\underline{F}$ = 6.95, $\underline{df}$ = 3/20, $\underline{p} < .002$) and across trials ($\underline{F}$ = 5.10, $\underline{df}$ = 5/100, $\underline{p} < .005$). The group by trial interaction was marginally reliable ($\underline{p} < .05$). Individual t-tests indicated that Groups 2, 6, and 12 were not significantly different from each other, but that Group 36 suppressed substantially less than the other three groups.

The above data analysis suggests that conditioning found in Groups 2, 6, and 12 dissipated with increased exposure to truly random training until in Group 36 no conditioned suppression was apparent.

Six individual suppression ratios out of 144 were lost due to the animals' failure to respond before the CS presentation. The lost scores were estimated based on the average of the suppression ratios of the two nearest trials. In the analysis of variance, degrees of freedom were adjusted accordingly.

Discussion

In Experiment 1 one group of subjects was exposed to the .66-.10- .07 truly random control used by Benedict and Ayres (1972). The remaining groups received the same sequence followed by similar random sequences making their total exposure to the truly random treatment 3,6, or 18 times as long as that of the original .66-.10-.07 sequence. Conditioning was replicated in the .66-.10-.07 random sequence used by Benedict and Ayres (1972). In addition, groups receiving 3 and 6 times the original amount of truly random training also showed conditioning. However, in the group receiving a sequence 18 times longer than the original sequence, conditioning was not found.

These findings are consistent with the evidence presented by Rescorla (1972) in showing that conditioning due to a brief exposure to the truly random control weakens with extended exposure. Moreover, they extend Rescorla's findings to treatments which, in their brief form, produce strong conditioned effects and in which CSs and USs are far more massed (i.e., temporally contiguous) than was the case in Rescorla's experiment.

One interpretation of these findings is that subjects exposed to chance pairings early in a truly random treatment detect a contingency caused by the first few chance pairings and therefore condition. Prolonged exposure to the treatment, however, provides them additional opportunity to learn that the CS is actually a poor predictor of US onset. At that point conditioning extinguishes.

Experiment 2

In Experiment 1, Group 2 was exposed to a brief truly random sequence of tone (CS) and shock (US) presentations. Later the group suppressed strongly to the CS when it was superimposed on bar-pressing. Group 36 was exposed to the same treatment as Group 2 plus 34 additional sessions of truly random training. This group however, did not suppress to the test CS when it was presented later. These results suggested that both groups conditioned to the tone as a result of early chance CS-US pairings but that Group 36 had more opportunity to learn that the CS did not really provide reliable information about the onset of USs; therefore, its conditioning extinguished.

An alternative hypothesis is that extended exposure to truly random training may have promoted a discrimination between the training condition in which USs were presented and the testing condition in which they were not. The possibility exists that an animal which has formed this discrimination will not suppress in the test session because he does not anticipate the presentation of any shocks in the test condition.

Taking a less theoretical approach, if one asks the question, what is the difference between the treatment given to Group 36 and that given to Group 2, one can see that Group 36 received many events that Group 2 did not receive. Group 36 received 34 additional sessions in the conditioning apparatus, 120 additional chance pairings, 1,062 additional

CSs alone, and 60 additional USs alone. It may be that all these events were necessary to produce the weakening of suppression noted or it may be that only one or two of these events were sufficient. The discrimination hypothesis described above might suggest that 34 additional sessions containing only chance pairings would enable the animals to discriminate between training conditions where shocks were presented and test conditions where they were not.

Alternately, the "information view" might hold that something in addition to extra sessions and extra pairings is required to persuade the animal that the CS is not a reliable predictor of the US onset. From this point of view, it may be that either CSs or USs alone are sufficient to make the CS uninformative; or it may be that both CSs and USs must occur alone.

Experiment 2 was conducted to determine which of these events were the necessary and sufficient conditions to produce weakening and elimination of conditioning found after the extended exposure to the truly random treatment of Benedict and Ayres (1972).

Experiment 2

Method

Subjects

Forty-two 90-day old male albino rats were acquired from the Holtzman Company, Madison, Wisconsin. After one week of exposure to the colony, the Ss were reduced to 80% of their ad-lib weights. This weight was maintained for the duration of the study.

Apparatus

The apparatus was that of Experiment 1.

Procedure

The procedure was identical in all respects to that used in Experiment 1 except for the treatments given in "truly random training." Briefly, truly random training consisted of six distinct procedures, of which only 2 actually qualify as truly random treatments. Each of six groups was treated by one of the six procedures.

Group 2 (N=12) was exposed only to the two-day truly random sequence of Benedict and Ayres (1972) and was tested immediately after training and operant recovery as in Experiment 1.

Group 2+PCUT (N=6) received the exact treatment given to Group 2 but then received 34 sessions of additional time (T) in the conditioning apparatus, 120 additional chance pairings (P), 1,062 additional CSs alone (C), and 60 additional

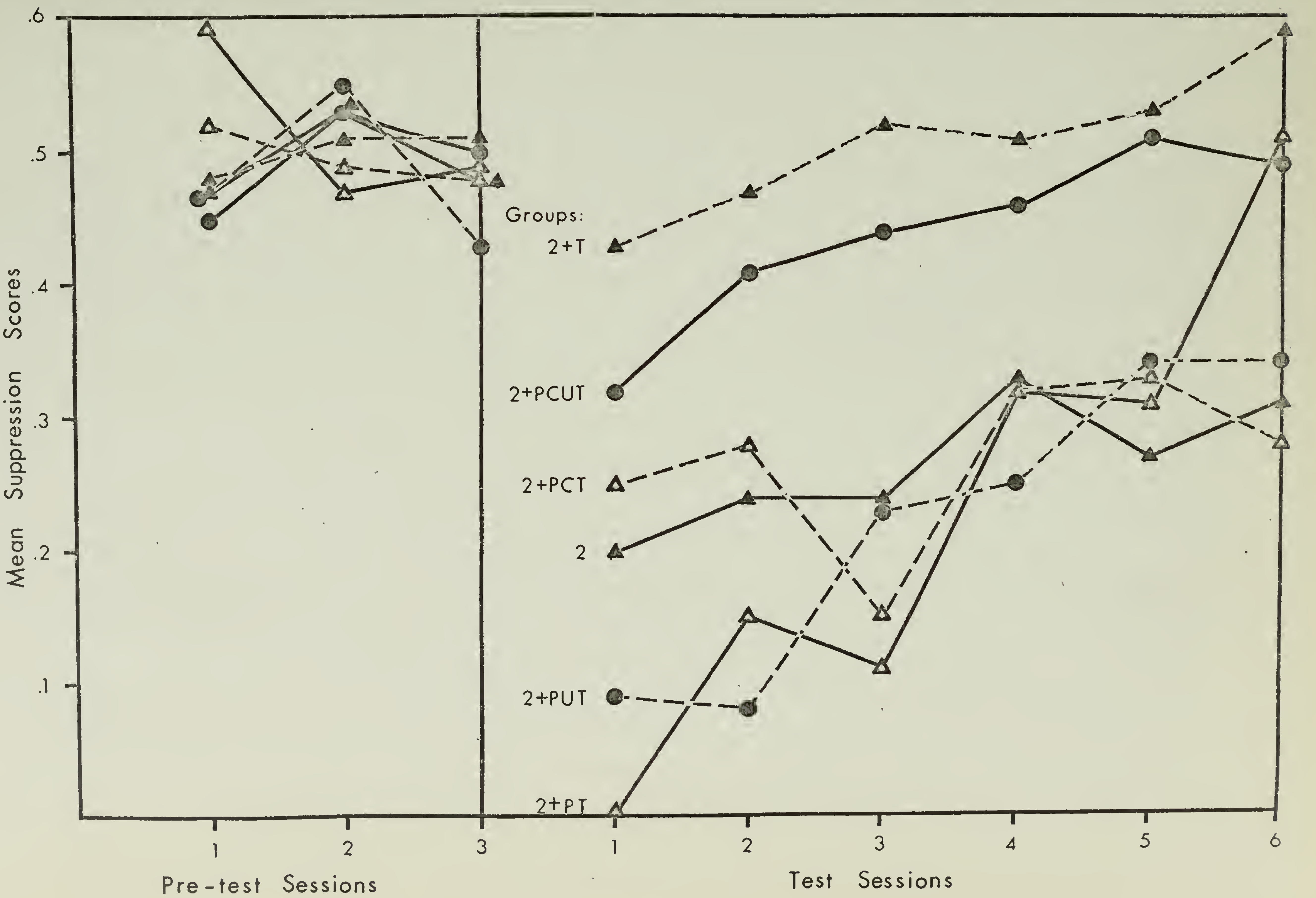
USs alone (U). In short, this group received the same treatment given to Group 36 in Experiment 1.

The remaining treatments were variants of that given to Group 2+PCUT. The treatments should be clear from the group designations. The remaining groups (N=6 in each) were designated Group 2+PUT, Group 2+PCT, Group 2+PT, and Group 2+T. All groups receiving the 34 additional sessions were "yoked" in the sense that they all received the same number and temporal distribution of the events they shared in common, i.e. P, C, U, or T.

In accordance with the information view proposed, one would expect the animals from Group 2+PCUT to demonstrate little or no conditioning while Group 2+PT should show very strong conditioning in the CS alone test procedure. Groups 2 and 2+T should also show strong conditioning but not as strong as Group 2+PT. Groups 2+PUT and 2+PCT should condition less than Groups 2 and 2+T but more than Group 2+PCUT.

Alternatively, under the proposed discrimination hypothesis, Groups 2 and 2+T should show strong conditioning while Groups 2+PCUT, 2+PCT, and 2+PT should show little or no conditioning when tested. In the procedure, all four of the latter groups receive 34 additional sessions in which shocks occur. According to the discrimination hypothesis, it is this experience that facilitates the discrimination between the training situation in which shocks occur and the test situation in which they do not occur.

Fig. 2 Effects of extended exposure to various components of the truly random procedure on conditioned suppression of bar pressing in Experiment 2.


.6
.5
.4
.3
.2
.1
Mean Suppression Scores
Groups:
2+T
2+PCUT
2+PCT
2
2+PUT
2+PT
1
2
3
1
2
3
4
5
6
Pre-test Sessions
Test Sessions

Results

Figure 2 shows the group mean suppression ratios for both pretest and test sessions. As in Experiment 1 the six groups did not differ significantly in terms of either their pretest suppression ratios or their pre-CS response rates (shown in Appendices D and F). The suppression ratios for the pretest sessions were at a level to indicate no suppression to the CS (Appendix P). Thus, between-group differences in suppression to the CS in the test sessions were not confounded with pretest differences or differences in base line response rates.

Figure 2 also shows that after truly random training, Group 2 suppressed to CS presentation, thus replicating the conditioning produced by that treatment in Experiment 1 and in Benedict and Ayres (1972). Group 2+PCUT did not suppress much to the CS, thus replicating the results of Group 36 in Experiment 1. Group 2+PT strongly suppressed to the CS, while Groups 2+PUT and 2+PCT showed intermediate levels of conditioning. Group 2+T demonstrated no suppression to the test CS presentation.

Across test trials, all groups showed an decrease in their suppression scores, suggesting an extinction of conditioning as a result of the CS alone test procedure.

A comprehensive (unequal N) analysis of variance was performed on the suppression ratios averaged across the six test sessions. The between group effect was found to be significant ($\underline{F}$ = 4.73, $\underline{df}$ = 5/36, $\underline{p} > .002$).

Individual t-tests indicated that Groups 2+PCUT and 2+T were suppressed significantly less than Group 2 (*p*'s = .02). The remaining groups did not differ significantly from Group 2 (*p*'s > .05).

Discussion

In Experiment 2, one group was exposed to only the brief truly random sequence used in Experiment 1 and in Benedict and Ayres (1972). Another group received the same sequence plus 34 additional sessions of similar truly random training. The remaining groups were exposed to the sequence of Benedict and Ayres (1972), plus 34 similar training sessions containing various components of the truly random control.

Conditioning was again replicated in the .66-.10-.07 random sequence of Benedict and Ayres (1972). Extinction of conditioning was again demonstrated when animals were subjected to the extended exposure of truly random training as in Experiment 1. The remaining groups exposed to various components of truly random training demonstrated various amounts of conditioning depending upon the particular group.

In general, the rank ordering of the groups, with the exception of Group 2+T, was reasonably consistent with that predicted by the information hypothesis described in the introduction to this experiment. More specifically, when animals were exposed to two days of truly random training plus 34 days of just pairings and time (Group 2+PT) strong conditioning was demonstrated. Interpreted in terms of the informational hypothesis, the 34 days of training did not permit these animals to learn that the CS was an unreliable predictor of US onset. In fact, during these 34 days, every CS was paired with a shock and no shocks occurred alone.

The CS therefore, was an excellent predictor and for this reason strong conditioning resulted.

Similarly, groups receiving 34 days of exposure to chance pairings and either CSs or USs alone (Groups 2+PCT and 2+PUT) demonstrate weaker conditioning than the group receiving only CS-US pairings (Group 2+PT). In accordance with the informational hypothesis, the animals exposed to the former treatments learn that the CS is not always a reliable predictor of US onset because either the CS or the US sometimes occurs alone. Therefore these animals do not condition as strongly as those exposed only to CS-US pairings.

Even less conditioning is found when both CSs and USs alone are presented in addition to chance pairings (Group 2+PCUT). This finding is consistent with the informational view since occurrence of both CS and US events alone should make the CS more unreliable than the occurrence of either event alone. In fact, the present data suggest that neither of these events alone is sufficient to eliminate the conditioning produced by the chance pairings in the truly random control. Instead, the occurrence of both events alone appears to be necessary. The basis for this suggestion is that both Groups 2+PCT and 2+PUT showed reasonably strong conditioning in the test, but Group 2+PCUT did not.

The one result which was clearly inconsistent with the informational view was the finding that Group 2+T showed no conditioning in the test. According to the informational view, this group had no opportunity in its 34 days of exposure to the apparatus cues to learn that the CS was an unreliable predictor of shock. Therefore it should have shown strong conditioning.

In addition to offering reasonable support for the informational view (with the exception noted), the data of this experiment offer strong disconfirmation of the alternative discrimination hypothesis proposed to account for the results of Experiment 1. According to this hypothesis Group 36 in Experiment 1 (and Group 2+PCUT in Experiment 2) failed to suppress in the test sessions because subjects in these groups formed a discrimination between the training situation in which shocks occur and the test in which they do not. It was hypothesized that 34 days of exposure to shocks in the training situation was responsible for this discrimination. Since Groups 2+PCT, 2+PUT, and 2+PT all received exposure to shocks for 34 additional days, they too should have shown little or no conditioning in the test. As indicated above, however, they all suppressed strongly to the CS in the test.

A procedural difference between the studies showing good retention of suppression and the present demonstration of poor retention is that in the former studies, the subjects spent the retention interval exclusively in their home cages. In contrast, in the present study subjects spent 1,000 sec. per day in the conditioning apparatus without shocks. It is possible that these animals learned that shocks were no longer delivered during these sessions and therefore did not suppress to the CS in the test situation. It is also possible, however, that due to sampling error Group 2+T was composed primarily of non-conditioners. Perhaps their CR was not forgotten but was, instead, never acquired.

Experiment 3 examined this possibility.

Experiment 3

If Group 2+T in Experiment 2 had by chance been composed of non-conditioners, then suppression in these animals should be very weak following re-exposure to the original truly random training sequence. On the other hand, it it possible the animals learned "safety" to apparatus cues during the 34-day retention interval, then re-exposure to the truly random procedure might be expected to reinstate the CR. Certainly, strong conditioning in Group 2+T following re-exposure to truly random training would be strong evidence against the suggestion that the group was composed of non-conditioners. In the present experiment five of the six groups run in Experiment 2 were re-exposed to two days of truly random training, then, after baseline recovery, were tested for conditioned suppression. The sixth group (Group 2) was no longer available for experimentation.

Method

Subjects

Thirty of the forty-two subjects from Experiment 2 were used in Experiment 3.

Apparatus

The apparatus was the same as that in Experiments 1 and 2.

Procedure

On the day following the last session of Experiment 2, five of the six groups from that experiment were re-exposed to the .66-.10-.07 random sequence of Benedict and Ayres (1972). The treatment was identical in all respects to that given Group 2 in Experiments 1 and 2. Following the truly random training each group was given one day of operant recovery as in Experiment 2. Following base-line recovery, testing consisted of two sessions in which conditioned suppression to the tone (CS) was measured as in Experiments 1 and 2.

TABLE 1

AVERAGE SUPPRESSION SCORES FOR GROUPS IN EXPERIMENT 2 AND 3

	GROUPS					
	2	2+PCUT	2+PUT	2+PCT	2+PT	2+T
Expt. 2 last two test sessions (avg.)	.29	.50	.34	.31	.41	.56
Expt. 3 first two test sessions (avg.)	N.A.	.45	.39	.32	.36	.14

Results

Table 1 shows the group mean suppression ratios averaged over the last two days of test sessions in Experiment 2 and the first two days of test sessions in Experiment 3. All group suppression ratios for the last two test sessions of Experiment 2 were at a level to indicate weak suppression to the test CS. However, after re-exposure to the .66-.10-.07 random sequence of Benedict and Ayres (1972) Group 2+T suppressed strongly to the test CS, Group 2+PUT, 2+PCT and 2+PT all demonstrated suppression at intermediate levels between Groups 2+PCUT and 2+T.

An analysis of variance was performed between the group mean suppression ratios in Experiment 3. The results showed a significant difference between groups ($F = 3.64$, $\underline{df} = 4/25$, $\underline{p} < .01$).

A $\underline{t}$-test indicated that Group 2+T suppressed more after reconditioning than before it ($\underline{t} = 3.22$, $\underline{df} = 25$, $\underline{p} < .01$).

Discussion

In Experiment 3 strong conditioning was demonstrated in Group 2+T following re-exposure to the two-day random sequence while no conditioning was shown in the remaining groups. These results suggest strongly that Group 2+T was not composed of non-conditioners. Failure to find suppression in this group in Experiment 2, therefore, cannot reasonably be attributed to a sampling error.

Research in the area of retention of the conditioned emotional response (Gleitman and Holmes, 1967; Hoffman, Selekman, and Fleshler, 1966; Kremer, 1971) and testing the retention of conditioning after exposure to the truly random control has demonstrated conditioning even when the animals are retained for a period of up to 2 1/2 years. One must consider that all animals in this research have been kept in the home cages during the retention interval, while the animals in Experiment 3 were exposed to apparatus cues during the retention interval. It seems plausible that during this extended exposure to the apparatus without shocks the subjects could have learned that shocks were no longer forthcoming. Hence there would be little reason to suppress during test sessions (c.f. Spear, N.E., 1973).

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Footnote

1. Predictions about the outcome of Experiment 1 and 2, based on the recent mathematical model of Rescorla and Wagner (1970) are discussed in Appendix J.

Appendices

List of Appendices

List of Appendices (cont.)

Appendix A

PRE-CS RESPONSE RATES-EXPERIMENT 1

PRE-CS RESPONSE RATES-EXPERIMENT 1

(Responses Per Minute)

Subjects	Sessions								
	Pre-test			Test					
Group 2	1	2	3	1	2	3	4	5	6
1	14	13	22	17	18	14	17	20	16
2	19	22	19	15	12	08	16	20	18
3	14	23	21	24	22	17	23	18	22
4	14	13	18	18	16	11	17	13	13
5	16	12	20	19	12	17	19	15	07
6	07	18	13	26	24	22	21	19	21
$\overline{X}$	14.00	16.83	18.83	19.83	17.33	14.83	18.83	17.50	16.16
Group 6	1	2	3	1	2	3	4	5	6
1	23	10	15	00(13*)	15	08	23	11	05
2	28	18	19	19	18	17	12	17	14
3	18	16	14	15	10	09	12	11	16
4	14	15	17	13	16	15	19	15	19
5	11	11	16	13	13	11	17	10	00
6	08	05	19	06	18	12	17	11	15
$\overline{X}$	17.00	12.50	16.66	13.17	15.00	12.00	16.66	12.50	11.50

PRE-CS RESPONSE RATES-EXPERIMENT 1

Subjects	Sessions								
	Pre-test			Test					
Group 12	1	2	3	1	2	3	4	5	6
1	20	21	16	01(19.50*)	18	21	24	18	18
2	19	14	20	06	17	21	20	19	27
3	16	19	18	15	19	16	11	28	21
4	11	11	12	00(8*)	00(8*)	00(8*)	09	07	06
5	32	18	13	23	23	19	23	28	28
6	07	07	03	06	13	15	06	10	07
$\overline{X}$	17.50	15.00	13.66	12.91	16.33	16.67	15.50	18.33	17.83
Group 36	1	2	3	1	2	3	4	5	6
1	16	23	27	13	21	07	16	12	14
2	21	30	18	23	17	24	17	19	21
3	24	25	20	18	12	05	11	14	14
4	15	14	21	07	10	11	16	21	24
5	31	17	18	13	11	06	13	13	11
6	19	10	16	15	15	05	14	10	13
$\overline{X}$	21.00	19.83	20.00	14.83	14.83	9.67	14.50	14.83	16.17

* Estimated values determined by averaging the next two consecutive days on which responses were recorded.

Appendix B

RESPONSE RATES DURING CS-EXPERIMENT 1

RESPONSE RATES DURING CS-EXPERIMENT 1

(Responses Per Minute)

Subjects	Sessions								
	Pre-test			Test					
Group 2	1	2	3	1	2	3	4	5	6
1	21	15	21	01	00	00	00	01	00
2	15	19	15	00	00	03	03	12	05
3	27	21	27	01	02	06	08	00	00
4	18	17	25	00	00	00	00	02	07
5	20	19	20	00	00	00	08	00	09
6	13	22	13	25	22	19	18	27	21
$\overline{X}$	19.00	18.83	20.17	4.50	4.00	4.67	6.17	7.00	7.00
Group 6	1	2	3	1	2	3	4	5	6
1	17	10	15	00(11*)	16	06	15	17	18
2	24	17	30	08	16	08	03	19	16
3	10	19	13	11	02	10	09	12	13
4	08	13	20	01	12	15	16	16	19
5	06	17	16	00	00	00	00	13	06
6	08	10	20	05	16	16	16	14	18
$\overline{X}$	12.68	14.33	19.00	6.00	10.33	9.17	9.83	15.17	15.00

RESPONSE RATES DURING CS-EXPERIMENT 1

(Responses Per Minute)

Subjects	Sessions								
	Pre-test			Test					
Group 12	1	2	3	1	2	3	4	5	6
1	20	28	17	00(16*)	16	16	20	14	17
2	15	17	21	08	15	23	18	25	23
3	15	18	14	00	04	01	11	23	15
4	09	13	10	01	01	01	01	01	01
5	27	15	12	02	06	10	13	16	19
6	01	06	02	00	00	00	00	02	00
$\overline{X}$	14.50	16.17	12.67	4.50	7.00	8.50	10.50	13.50	12.50
Group 36	1	2	3	1	2	3	4	5	6
1	17	20	26	15	24	16	16	12	14
2	19	25	21	29	18	20	19	19	22
3	27	22	16	28	19	19	14	19	19
4	13	17	12	15	07	10	10	09	25
5	20	08	25	03	10	09	15	13	16
6	13	18	16	15	14	08	12	06	13
$\overline{X}$	18.17	18.33	19.33	17.50	15.33	13.67	14.33	13.00	18.17

* Estimated value determined by averaging the next two consecutive days on which responses were recorded.

Appendix C

SUPPRESSION RATIOS-EXPERIMENT 1

SUPPRESSION RATIOS-EXPERIMENT 1

Subjects	Sessions								
	Pre-test			Test					
Group 2	1	2	3	1	2	3	4	5	6
1	.58	.54	.49	.06	.00	.00	.00	.05	.00
2	.44	.46	.44	.00	.00	.27	.16	.38	.22
3	.44	.48	.56	.04	.08	.26	.26	.00	.00
4	.52	.57	.58	.00	.00	.00	.00	.13	.35
5	.48	.61	.50	.00	.00	.00	.30	.00	.56
6	.42	.55	.50	.49	.48	.46	.46	.59	.50
$\overline{X}$	.48	.53	.51	.10	.09	.17	.20	.19	.27
Group 6	1	2	3	1	2	3	4	5	6
1	.43	.50	.50	.45*	.52	.43	.39	.61	.55
2	.46	.49	.61	.30	.47	.32	.20	.53	.53
3	.36	.54	.48	.42	.17	.53	.43	.52	.45
4	.36	.53	.54	.07	.43	.50	.46	.52	.50
5	.35	.61	.50	.00	.00	.00	.00	.57	1.00
6	.44	.67	.51	.15	.47	.57	.48	.56	.55
$\overline{X}$	.41	.56	.52	.28	.34	.39	.33	.55	.66

SUPPRESSION RATIOS-EXPERIMENT 1

Subjects	Sessions								
	Pre-test			Test					
Group 12	1	2	3	1	2	3	4	5	6
1	.50	.57	.52	.45*	.47	.43	.45	.44	.49
2	.44	.55	.51	.50	.47	.52	.47	.57	.46
3	.48	.49	.44	.00	.17	.06	.31	.45	.42
4	.45	.54	.45	.11*	.11*	.11*	.10	.13	.14
5	.46	.45	.48	.08	.21	.34	.36	.36	.40
6	.13	.46	.40	.00	.00	.00	.00	.17	.00
$\overline{X}$	.41	.51	.47	.19	.24	.24	.28	.35	.32
Group 36	1	2	3	1	2	3	4	5	6
1	.52	.47	.49	.54	.53	.70	.50	.50	.50
2	.47	.45	.54	.56	.51	.45	.53	.63	.51
3	.53	.47	.44	.61	.61	.79	.56	.58	.58
4	.46	.55	.36	.68	.41	.59	.56	.30	.51
5	.39	.32	.58	.19	.48	.41	.54	.50	.59
6	.41	.64	.50	.50	.48	.62	.46	.38	.50
$\overline{X}$	.46	.48	.49	.51	.51	.59	.52	.48	.53

* Estimated scores calculated by averaging the next two consecutive sessions in which a suppression score was obtained.

Appendix D

PRE-CS RESPONSE RATES-EXPERIMENT 2

PRE-CS RESPONSE RATES-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	13	14	24	20	19	19	28	08	24
2	33	21	19	15	18	18	22	29	07
3	18	20	30	27	28	22	24	23	25
4	31	12	11	12	20	06	14	20	17
5	33	21	26	41	23	16	23	15	47
6	30	25	26	17	21	20	20	26	20
7	24	22	20	23	35	28	17	24	22
8	23	10	20	23	18	24	17	34	28
9	24	28	20	12	21	18	18	28	15
10	21	25	17	10	13	07	13	23	13
11	30	14	27	20	16	28	22	26	26
12	23	19	21	16	12	19	22	23	21
$\overline{X}$	25.25	19.25	21.75	19.67	20.33	18.75	20.00	23.25	22.08

PRE-CS RESPONSE RATES-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2+PCUT	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	26	32	24	28	22	22	25	17	22
2	14	34	16	18	19	17	15	14	18
3	15	23	18	16	22	22	25	21	21
4	12	27	17	18	20	19	12	19	27
5	17	07	26	12	19	22	20	19	22
6	22	30	15	13	08	05	06	22	27
$\overline{X}$	17.67	25.50	19.33	17.50	18.33	17.83	17.17	18.67	22.83
Group 2+PUT									
	1	2	3	1	2	3	4	5	6
1	17	18	17	17	35	19	17	16	18
2	32	18	22	19	16	13	14	18	32
3	20	20	29	18	19	20	20	20	19
4	17	15	20	11	23	26	21	24	35
5	23	24	27	05	28	19	25	05	25
6	27	19	25	31	30	26	23	22	22
$\overline{X}$	22.67	19.00	23.33	16.83	25.17	20.50	20.00	17.50	25.17

PRE-CS RESPONSE RATES-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2+PCT	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	24	18	20	16	17	25	21	21	27
2	18	18	27	19	18	21	23	13	22
3	22	25	18	21	17	22	28	29	27
4	11	17	19	23	18	18	08	19	15
5	10	36	16	08	12	15	12	26	13
6	25	21	32	20	21	23	26	35	21
$\overline{X}$	18.33	22.50	22.00	17.83	17.17	20.67	19.67	23.83	20.83
Group 2+PT									
	1	2	3	1	2	3	4	5	6
1	20	21	23	24	23	21	24	13	21
2	11	18	19	14	13	19	16	16	14
3	23	29	27	24	26	21	28	22	30
4	19	22	19	23	20	18	17	01	18
5	14	18	21	24	28	21	16	24	08
6	07	17	25	16	14	20	17	14	18
$\overline{X}$	15.67	20.83	22.33	20.83	20.67	20.00	19.67	15.00	18.17

PRE-CS RESPONSE RATES-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2+T	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	17	20	26	18	16	14	14	13	12
2	14	22	19	12	21	17	17	24	19
3	24	18	15	19	15	13	14	14	12
4	12	13	08	13	15	08	19	14	16
5	21	18	20	21	16	26	27	16	17
6	12	17	24	20	25	26	15	12	14
$\overline{X}$	16.67	18.00	18.67	17.17	18.00	17.33	17.67	15.50	15.00

Appendix E

RESPONSE RATES DURING THE CS-EXPERIMENT 2

RESPONSE RATES DURING CS-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	20	19	19	00	00	00	21	11	05
2	20	16	22	00	00	00	19	02	00
3	24	25	25	02	19	11	00	00	15
4	15	18	13	10	25	11	13	14	12
5	30	21	29	00	04	00	08	00	19
6	23	25	17	14	01	10	18	23	03
7	27	25	22	04	21	20	10	23	27
8	20	13	27	17	09	26	00	12	22
9	35	29	25	00	00	00	18	00	00
10	20	22	17	09	16	04	08	06	10
11	33	16	09	00	00	06	01	06	21
12	23	22	18	08	10	13	21	17	20
$\overline{X}$	24.17	20.92	20.25	5.33	8.75	8.42	11.42	9.50	12.83

RESPONSE RATES DURING CS-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2+PCUT	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	12	33	15	16	22	16	24	22	21
2	10	33	14	16	14	19	17	21	13
3	21	28	37	31	22	26	29	22	28
4	09	29	13	02	16	21	17	22	21
5	21	10	27	00	13	17	00	11	28
6	15	34	17	07	02	08	08	20	10
$\overline{X}$	14.67	27.83	20.50	12.00	14.83	17.83	15.83	19.67	20.17
Group 2+PUT									
	1	2	3	1	2	3	4	5	6
1	18	17	17	01	08	02	02	03	09
2	20	20	22	00	01	02	00	11	17
3	25	26	29	36	35	16	21	19	19
4	15	20	12	00	00	07	14	25	30
5	19	31	16	00	00	00	00	00	01
6	22	26	26	25	06	01	24	22	12
$\overline{X}$	19.83	23.33	20.33	10.33	8.33	4.67	10.17	13.33	14.67

RESPONSE RATES DURING CS-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2+PCT	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	26	20	15	19	17	21	21	01	27
2	18	19	24	13	16	17	21	01	15
3	26	24	17	04	05	01	27	19	26
4	11	13	15	15	13	13	00	21	00
5	13	37	17	00	00	00	00	25	00
6	25	20	38	00	01	01	22	29	08
$\overline{X}$	19.83	22.17	21.00	8.50	8.67	8.83	15.17	16.00	12.67
Group 2+PT									
	1	2	3	1	2	3	4	5	6
1	27	21	22	00	00	00	13	15	25
2	15	11	12	00	00	00	04	06	17
3	45	29	24	00	07	13	21	20	25
4	12	12	21	00	11	00	09	00	18
5	18	24	26	00	24	00	21	25	08
6	24	18	25	00	12	13	00	00	19
$\overline{X}$	23.50	19.17	21.67	.00	9.00	4.33	11.33	11.00	18.67

RESPONSE RATES DURING CS-EXPERIMENT 2

(Responses Per Minute)

Subjects	Sessions								
Group 2+T	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	18	16	22	18	11	15	19	15	19
2	18	18	20	19	24	17	14	06	20
3	17	21	15	23	12	24	22	27	25
4	06	10	07	13	19	11	19	15	21
5	17	27	20	00	13	24	25	35	26
6	17	22	26	14	19	19	12	16	19
$\overline{X}$	15.50	19.00	18.33	14.50	16.33	18.33	18.50	19.00	21.67

Appendix F

SUPPRESSION RATIOS-EXPERIMENT 2

SUPPRESSION RATIOS-EXPERIMENT 2

Subjects	Sessions								
Group 2	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	.61	.58	.44	.00	.00	.00	.43	.58	.17
2	.38	.43	.54	.00	.00	.00	.46	.07	.00
3	.57	.56	.46	.07	.40	.33	.00	.00	.38
4	.33	.60	.54	.46	.56	.65	.48	.41	.41
5	.48	.50	.53	.00	.15	.00	.26	.00	.29
6	.43	.50	.40	.45	.05	.32	.47	.47	.13
7	.53	.53	.52	.15	.38	.42	.37	.49	.55
8	.47	.57	.58	.43	.33	.52	.00	.26	.44
9	.59	.51	.56	.00	.00	.00	.50	.00	.00
10	.49	.47	.50	.47	.55	.36	.38	.21	.44
11	.52	.53	.25	.00	.00	.18	.04	.19	.45
12	.50	.54	.46	.33	.46	.41	.49	.43	.49
$\overline{X}$	.49	.53	.48	.20	.24	.27	.32	.27	.31

SUPPRESSION RATIOS-EXPERIMENT 2

Subjects	Sessions								
Group 2+PCUT	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	.32	.51	.39	.36	.50	.42	.49	.56	.49
2	.42	.49	.47	.47	.42	.53	.53	.60	.42
3	.58	.55	.67	.66	.50	.54	.54	.51	.57
4	.43	.52	.43	.10	.44	.53	.59	.54	.44
5	.55	.59	.51	.00	.41	.43	.00	.37	.56
6	.41	.53	.53	.35	.20	.62	.57	.48	.27
$\overline{X}$	.45	.53	.50	.32	.41	.51	.45	.51	.46
Group 2+PUT									
	1	2	3	1	2	3	4	5	6
1	.51	.49	.50	.06	.19	.10	.11	.16	.33
2	.39	.53	.50	.00	.06	.13	.00	.38	.35
3	.56	.57	.50	.67	.65	.44	.51	.49	.50
4	.47	.57	.38	.00	.00	.21	.40	.51	.46
5	.45	.56	.37	.00	.00	.00	.00	.00	.04
6	.45	.58	.51	.45	.17	.04	.51	.50	.35
$\overline{X}$	.47	.55	.46	.20	.18	.15	.26	.34	.34

SUPPRESSION RATIOS-EXPERIMENT 2

Subjects	Sessions								
Group 2+PCT	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	.52	.53	.43	.54	.50	.47	.50	.05	.50
2	.50	.51	.47	.41	.47	.45	.48	.07	.41
3	.54	.49	.49	.16	.23	.04	.49	.40	.49
4	.50	.43	.44	.40	.42	.41	.00	.53	.00
5	.57	.51	.52	.00	.00	.00	.00	.49	.00
6	.50	.49	.54	.00	.05	.04	.46	.45	.28
$\overline{X}$	.52	.49	.48	.25	.28	.24	.32	.33	.28
Group 2+PT									
	1	2	3	1	2	3	4	5	6
1	.57	.50	.49	.00	.00	.00	.35	.54	.54
2	.58	.38	.39	.00	.00	.00	.20	.27	.55
3	.66	.50	.47	.00	.21	.38	.43	.48	.45
4	.39	.35	.52	.00	.35	.00	.35	.00	.50
5	.56	.57	.55	.00	.46	.00	.57	.51	.50
6	.77	.51	.50	.00	.46	.39	.00	.00	.51
$\overline{X}$	.59	.47	.49	.00	.25	.13	.32	.30	.51

SUPPRESSION RATIOS-EXPERIMENT 2

Subjects	Sessions								
Group 2+T	Pre-test			Test					
	1	2	3	1	2	3	4	5	6
1	.51	.44	.46	.50	.41	.52	.58	.54	.61
2	.56	.45	.51	.60	.53	.50	.45	.20	.51
3	.42	.54	.50	.55	.44	.65	.61	.66	.68
4	.33	.43	.47	.50	.56	.58	.50	.52	.57
5	.45	.60	.50	.00	.45	.48	.48	.68	.61
6	.59	.56	.52	.41	.43	.42	.44	.57	.58
$\overline{X}$	.48	.50	.49	.43	.47	.53	.51	.53	.59

Appendix G

PRE-CS RESPONSE RATES-EXPERIMENT 3

PRE-CS RESPONSE RATES-EXPERIMENT 3

Subjects	Group 2+PCUT		Group 2+PUT		Group 2+PCT	
	Sessions		Sessions		Sessions	
	1	2	1	2	1	2
1	20	24	18	15	15	24
2	17	15	29	28	22	30
3	22	19	24	23	29	20
4	22	32	16	23	10	17
5	18	18	29	30	10	03
6	16	15	26	20	24	37
$\overline{X}$	19.17	20.50	23.67	23.17	18.33	21.83

Subjects	Group 2+PT		Group 2+T	
	Sessions		Sessions	
	1	2	1	2
1	22	21	14	26
2	15	14	00	13
3	25	25	00	11
4	24	21	00	10
5	17	19	00	16
6	22	13	06	19
$\overline{X}$	20.83	18.33	3.33	15.83

Appendix H

RESPONSE RATE DURING CS-EXPERIMENT 3

RESPONSE RATES DURING CS-EXPERIMENT 3

Subjects	Group 2+PCUT		Group 2+PUT		Group 2+PCT	
	Sessions		Sessions		Sessions	
	1	2	1	2	1	2
1	28	24	19	13	14	25
2	21	18	02	16	17	36
3	23	20	24	24	09	17
4	22	22	15	17	00	22
5	17	19	09	02	01	00
6	09	18	25	23	04	23
$\overline{X}$	20.00	20.17	15.67	15.83	7.50	20.50

Subjects	Group 2+PT		Group 2+T	
	Sessions		Sessions	
	1	2	1	2
1	20	10	20	25
2	15	00	00	00
3	30	15	00	00
4	06	14	00	04
5	18	08	00	00
6	05	10	06	01
$\overline{X}$	15.67	9.50	4.33	5.00

Appendix I

SUPPRESSION RATIOS-EXPERIMENT 3

SUPPRESSION RATIOS-EXPERIMENT 3

Subjects	Group 2+PCUT		Group 2+PUT		Group 2+PCT	
	Sessions		Sessions		Sessions	
	1	2	1	2	1	2
1	.58	.50	.51	.46	.48	.51
2	.55	.55	.07	.36	.44	.55
3	.51	.51	.50	.51	.24	.45
4	.50	.41	.48	.43	.00	.56
5	.49	.51	.24	.06	.09	.00
6	.36	.55	.49	.53	.14	.38
$\overline{X}$	.50	.51	.38	.39	.23	.40

Subjects	Group 2+PT		Group 2+T	
	Sessions		Sessions	
	1	2	1	2
1	.48	.32	.58	.49
2	.50	.00	.00	.00
3	.55	.38	.00	.00
4	.20	.40	.00	.28
5	.51	.30	.00	.00
6	.19	.43	.50	.05
$\overline{X}$	.41	.31	.18	.14

Appendix J

PREDICTING CONDITIONING WITH THE RESCORLA-WAGNER MODEL

PREDICTING CONDITIONING WITH THE RESCORLA-WAGNER MODEL

In accordance with the Rescorla-Wagner model(1970) conditioning to a CS can occur only when the CS is temporally contiguous to a given US. The model also postulates that increments in conditioning to the CS as a result of pairings are inversely proportional to the conditioning strength already established by the compound of which the CS is an element. In terms of the truly random control, if a US occurs in the absence of a CS, conditioning will accrue to the apparatus cues and will result in a blocking effect for future CS-US pairings.

In terms of the model, the blocking effect is responsible for the absence of conditioning to the CS in the truly random control. However, Rescorla (1972) has described how conditioning can occur in the procedure. When CS-US pairings occur before a US alone trial, conditioning can accrue to the CS instead of to the apparatus cues. Then, if the reinforcing parameters are stronger than the extinction parameters, the initial conditioning established by early chance pairings may not have time to extinguish before the treatment ends. The model views such conditioning as being pre-asymptotic and suggests that after extended exposure to the procedure, the conditioning should extinguish.

The Rescorla-Wagner model provides a statistic which can predict the level of conditioning for any truly random control procedure. It is called the Vx statistic and increments on reinforced trials and decrements on non-reinforced trials. By computing Vx statistics for the sequences used in this report it should be possible to rank order these sequences in terms of the conditioning expected from them. However, the predictions are not parameter free. Before rank order predictions can be made, the values of four parameters in the model must be estimated from previous data. Ayres, Benedict, and Witcher (unpublished) have estimated the values of these parameters. These estimates provided rank order predictions that correlated well with the actual conditioning produced by thirteen truly random sequences (Spearman rho=.84). These parameter estimates were obtained too late to be included in the body of this report.

Since Ayres, Benedict, and Witcher used CSs and USs of the same duration and intensity as those used here, and since their apparatus and subjects, etc. were quite similar to those used here, the parameter estimates obtained should theoretically provide good rank order predictions about the sequences used in this research.

Figure 1A shows the predictions made about the sequences used in Experiment 1 and the actual suppression scores obtained. It can be seen that the model predicted the data with reasonable accuracy. In Figure 2A the predictions made about the sequences used in Experiment 2 are shown along with the actual scores obtained. It is clear that there are some large departures from the predictions. Notable among these departures is the suppression obtained in Group 2+T. The Rescorla-Wagner model, like the informational view and the discrimination hypothesis discussed in the body of this report makes no provision for forgetting.

Table 1J shows the predicted and obtained suppression scores for all the groups in Experiments 1 and 2. The table also shows the Spearman rank order correlations obtained both including and excluding Group 2+T.

It is clear from Table 1J that the correspondence between the group suppression scores predicted by the model and those actually obtained is fair but not excellent. If Group 2+T is excluded, the Spearman rank order correlation between the observed and predicted data is marginally reliable. In addition, a X^2 test performed on the observed and expected scores shown in the table did not reveal a significant difference between them ($\underline{X}^2=1.593$, $\underline{df}=10$, $\underline{p}$ .05). It must be concluded that the data do not permit a clear rejection of the model.

Table 1J Comparison of Predicted and observed suppression scores for experiment 1 and 2.

Table 1J

COMPARISON OF PREDICTED AND OBSERVED SUPPRESSION

SCORES FOR EXPERIMENTS 1 AND 2

Experiment 1

Groups	Predicted Group Suppression Scores	Actual Group Suppression Scores[a]
2	.13	.10
6	.25	.25
12	.38	.22
36	.48	.51

Experiment 2

Groups	Predicted Group Suppression Scores	Actual Group Suppression Scores
2+PCUT	.48	.37
2+PUT	.46	.19
2+PCT	.08	.27
2+PT	.05	.08
2+T	.13	.45
2(1)[b]	.13	.17
(2)	.13	.26

a. Spearman rank correlations were performed on the predicted and observed suppression scores in Experiment 1 and 2. The correlations were determined both including and excluding Group 2+T. A significant correlation was found (rho = +.57 $\underline{p}$ = .05, 1-tailed). When Group 2+T was excluded whereas, the correlation was not significant (rho = +.45, $\underline{p}$ > .05) when Group 2+T was included.

b. For statistical purposes Group 2 was divided into two Groups (N=6 in each).

Fig. 1A Predicted and observed suppression scores for Experiment 1.

Rescorla-Wagner Model

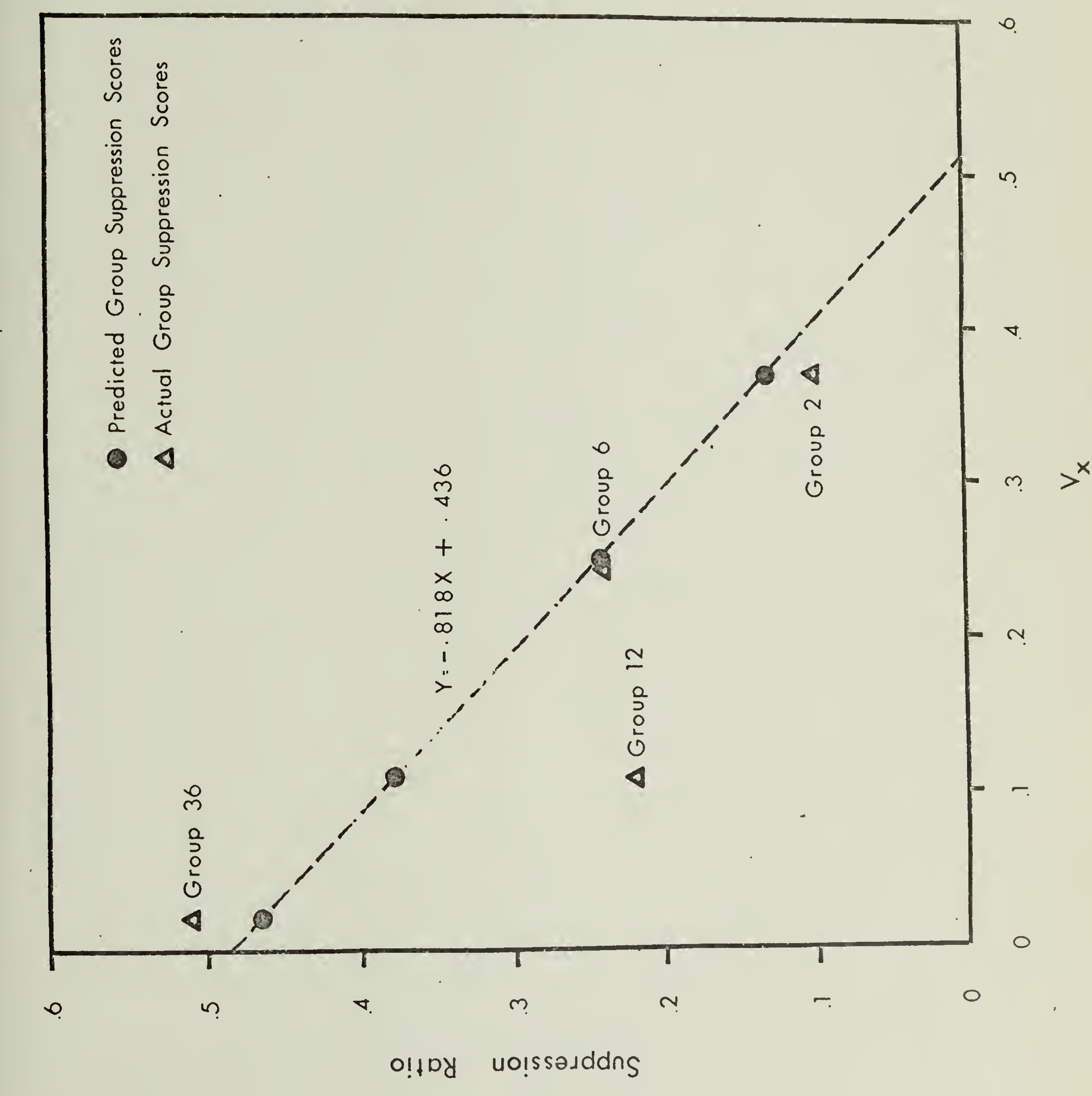
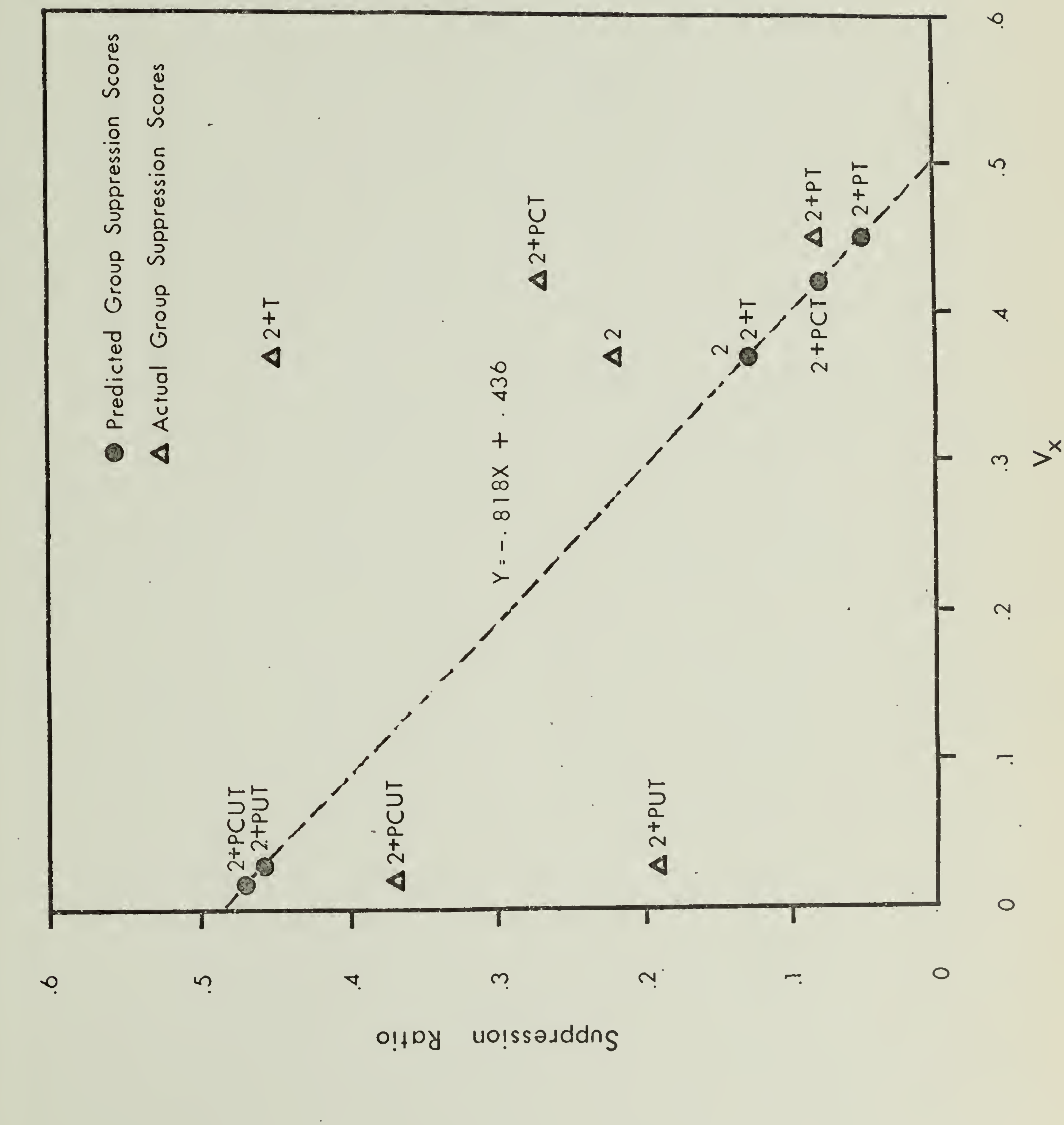


Fig. 2A Predicted and observed suppression scores for Experiment 2.

Rescorla – Wagner Model



Appendix K

COMPUTER PROGRAM USED TO MAKE PREDICTIONS FROM THE RESCORLA-WAGNER MODEL

PROGRAM RESCORLA 07/30/73 1121

```
1 PROGRAM MODEL2
2*RESCORLA AND WAGNER MODEL
4 DIMENSION PAIR(600),AA(600),AX(600),OCS(600)
5 DIMENSION P(100),CS(100),US(100),INT(1000)
6 REAL NOCS,NPP,NNCS,NNUS
7 INTEGER P,CS,US
8 VAX=0
9 VA=0
10 VX=0
11 READ,NCS,NUS,NP,NINT
12 DO 13 I=1,NINT
13 INT(I)=0
14 READ,(CS(I),I=1,NCS),(US(I),I=1,NUS),(P(I),I=1,NP)
15 BETA2=.0010000000
18 ALPHAA=.174167538
19 ALPHAX=.177733635
20 BETA1=.0300000000
21 DO 23 I=1,NINT
22 PAIR(I)=OCS(I)=0
23 INT(I)=0
40 DO 50 I=1,NCS
50 INT(CS(I))=3
52 DO 54 I=1,NUS
54 INT(US(I))=2
56 DO 58 I=1,NP
58 INT(P(I))=1
59 DO 115 M1=1,2
60 DO 105 I=1,NINT
66 KK=INT(I)+1
67 GOTO(90,68,76,82),KK
68 DVX=ALPHAX*BETA1*(1.0-VAX)
70 VX=VX+DVX
71 DVA=ALPHAA*BETA1*(1.0-VAX)
72 GO TO 92
76 DVA=ALPHAA*BETA1*(1.0-VA)
77 GO TO 92
82 DVX= ALPHAX*BETA2*(0-VAX)
83 DVA= ALPHAA*BETA2*(0-VAX)
84 VX=VX+DVX
85 GO TO 92
90 DVA=ALPHAA*BETA2*(0-VA)
92 VA=VA+DVA
100 VAX=VX+VA
101 AA(I)=ALPHAA
102 PAIR(I)=VX
103 OCS(I)=VA
104 AX(I)=ALPHAX
105 CONTINUE
110 PRINT 112
112 FORMAT(* INTERVAL        VX*,10X,*VA*)
114 PRINT 116,(I,PAIR(I),AX(I),OCS(I),AA(I),I=100,NINT,100)
```

```
115 CONTINUE
116 FORMAT(I5,3X,2F5.2,5X,2F5.2)
118 GO TO 11
120 END
130 ENDPROG
```

Appendix L

A FORTRAN COMPUTER PROGRAM WHICH GENERATES RANDOM PRESENTATIONS OF CSs AND USs

PROGRAM RANPAIR 07/25/73 1332

```
1 PROGRAM RANPAIR
2*PLACE SESSION LENGTH(SEC) AND LENGTH OF CS IN LINE 300
3 DIMENSION N(70),NUS(70),NCS(70),NCEKUS(2000),NCEKCS(2000)
5 READ,MAX,LENCS
6 PRINT 7
7 FORMAT(*LARGEST*/*NUMBER OF CSS*/*NUMBER OF USS*)
8 INPUT,NN,NUMCS,NUMUS
9 MIT=9
11 Z=1.0
12 X=TIMEF(Z)
13 CALL RANFSET(X)
14 DO 17 I=1,MAX
16 NCEKCS(I)=0
17 NCEKUS(I)=0
18 MIT=9
20 DO 100 I=1,NN
21 IF(MIT.EQ.0)100,22
22 LL=0
24 FORMAT(I5,5X,I5,5X,I5)
26 MIN=1
30 CALL RANDOM(MAX,MIN,NUMBER,LL)
32 IF(NCEKCS(NUMBER).EQ.1)30,33
33 IF((NUMBER+LENCS) .GT. MAX)30,34
34 DO 38 K=-(1+LENCS),LENCS+1
35 IF(K+NUMBER .LT. 1)38,36
36 IF((K+NUMBER) .GT. MAX)38,37
37 NCEKCS(NUMBER+K)=1
38 CONTINUE
39 NCS(I)=NUMBER
40 CALL RANDOM(MAX,MIN,NUMBER)
42 IF(NCEKUS(NUMBER) .EQ. 0)44,40
44 DO 48 K=-1,1
48 NCEKUS(NUMBER+K)=1
50 NUS(I)=NUMBER
60*CALL FIND
100 CONTINUE
103 IF(MIT .EQ. 0)11,104
104 CALL SORT(NUS,NUMUS)
105 CALL SORT(NCS,NUMCS)
106 CALL PAIR(NCS,NUS,NCEKCS,NUMCS,NUMUS,KO,LENCS)
107 PRINT 108,KO
108 FORMAT(//*SECOND LENGTH     CS              ITI   PAIRINGS=*,I5)
109 INPUT,MIT
110 IF(MIT .EQ.0)11,111
111 DO 114 I=1,NUMCS
112 PRINT 113,NCS(I),NCS(I)+LENCS-1,NCS(I+1)-(NCS(I)+LENCS)
113 FORMAT(I5,5X,I5,14X,I5)
114 WRITE (62,115)I,NCS(I)
115 FORMAT(S5,I7)
120 PRINT 121
121 FORMAT(//*SECOND              US              ITI*)
```

```
125 DO 128 I=1,NUMUS
126 PRINT 127,NUS(I),NUS(I+1)-NUS(I)
127 FORMAT(I6,23X,I5)
128 WRITE (62,129)I+NUMCS,NUS(I)
129 FORMAT(I5,I7)
177 CONTINUE
130 END
300 SUBROUTINE RANDOM(MAX,MIN,NUMBER,LL)
301 LL=0
302 YMAX=MAX
303 YMIN=MIN
304 NUMBER=((YMAX-YMIN+1.0)*RANF(-1))+YMIN
306 RETURN
308 END
400 SUBROUTINE SORT(N,NN)
402 DIMENSION N(1)
403 DO 420 J=1,NN
405 M=N(1)
406 DO 420 L=2,NN
407 IF(M .GT. N(L))408,414
408 N(L-1)=N(L)
409 N(L)=M
410 GO TO 420
414 M=N(L)
420 CONTINUE
422 RETURN
430 END
440 SUBROUTINE FIND(NCEKCS,K,KK,MIT)
445 DIMENSION NCEKCS(1),N(1)
447 K=0
450 DO 490 I=1,2000
460 IF(NCEKCS(I) .EQ. 0) 480,490
480 K=K+1
490 CONTINUE
491 L=1
492 IF(K .LT.15)495,520
495 DO 500 I=1,2000
497 IF(NCEKCS(I) .EQ. 0)498,500
498 N(L)=I
499 L=L+1
500 CONTINUE
504 DO 505 I=1,L-1
505 PRINT 506,KK,K,N(I)
506 FORMAT(10I5)
510 INPUT,MIT
520 RETURN
530 END
600 SUBROUTINE PAIR(NCS,NUS,NCEKCS,L,M,KO,LE)
602 DIMENSION NCS(1),NUS(1),NCEKCS(1)
604 KO=0
```

```
605 DO 608 K=1,L
606 DO 608 J=1,LE
608 NCEKCS(NCS(K)+J-1)=2
610 DO 614 K=1,M
612 IF(NCEKCS(NUS(K)) .EQ. 2)613,614
613 KO=KO+1
614 CONTINUE
619 RETURN
620 END
700 ENDPROG
800 1000,20
```

Appendix M

COMPUTER ASSIGNMENT OF CSs AND USs TO INTERVALS FOR THE GROUPS IN EXPERIMENTS 1 AND 2

LIST OF ACTUAL CS AND US INTERVALS PRESENTED

EACH DAY FOR EXPERIMENTS 1 AND 2

Day	Tape Number
1	1A
2	1B
3	4
4	3
5	8
6	5
7	11
8	6
9	9
10	10
11	7
12	12

Day 1 Tape 1A

Interval	Begin CS	Duration of CS	End CS	
1	3	(9)*	22	
3	31		50	
4	57		76	
6	99	(117)*	118	
7	126	(145)*	145	
9	168		187	
11	196		215	
12	218		237	
13	243		262	
14	268		287	
16	295		314	(327)**
18	347		366	
20	389		408	
22	411		430	
23	435		454	
24	459		478	
25	487		506	
27	513		532	
28	539		558	
29	561		580	
31	592		611	
32	614		633	
33	648		667	
36	691		710	
37	724		743	
38	746		765	
39	769		788	
42	816		835	
43	841	(849)*	860	
45	873		892	
47	911		930	
48	935		954	
49	959		978	

Interval	US Presentation (1 second)
1	9
6	117
7	145
17	327
43	849

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 2 Tape 1B

Interval	Duration of CS Begin CS		End CS	
51	1001		1020	
52	1027		1046	(1056)**
54	1060		1079	
55	1084		1103	(1110)**
57	1117		1136	
59	1162	(1172)*	1181	
60	1190		1209	
62	1219		1238	
63	1249		1268	
65	1272		1291	
66	1294		1313	
67	1318		1337	
68	1340		1359	
69	1362		1381	
70	1386	(1395,1400)*	1405	
72	1418		1437	
74	1462		1481	
76	1497		1516	
77	1527		1546	
78	1549		1568	
80	1573		1592	
81	1601		1620	
82	1623		1642	
84	1665		1684	
85	1689		1708	
88	1732		1751	
89	1758		1777	
90	1782		1801	
92	1818		1837	
94	1853		1872	
96	1895		1914	
98	1931		1950	
99	1960		1979	

Interval	US Presentation (1 second)
53	1056
56	1110
59	1172
70	1395
70	1400

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 3 Tape 4

Interval	Duration of CS Begin CS		End CS	
102	18		37	
104	51		70	
105	85		104	
106	108		127	
108	131		150	
109	164		183	
110	188		207	
112	214	(225)*	233	
113	244		263	
115	285	(285)*	304	
117	314		333	
118	341		360	
120	377	(377)*	396	
121	399		418	
122	422		441	(442)**
124	454		473	
125	480		499	
127	522		541	
129	560		579	
130	584		603	
132	621		640	
133	649		668	
135	678		697	
136	706		725	
138	736		755	
139	769		788	
141	792		811	
142	830		849	
144	852		871	
145	881		900	
146	903		922	
147	930		949	
149	956		975	(987)**

Interval	US Presentation (1 second)
112	225
115	285
120	377
123	442
150	987

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 4 Tape 3

Interval	Duration of CS Begin CS		End CS	
152	16		35	
154	54		73	
155	90		109	
157	124		143	
158	150		169	
160	189	(206)*	208	
162	219		238	
163	247		266	
165	274		293	
167	318		337	
168	346		365	
170	371		390	
171	396		415	
172	421		440	
173	446		465	
175	486		505	
177	512		531	
179	555		574	
180	577	(581)*	596	
182	615		634	
183	641		660	
185	671		690	
186	696		715	
187	726		745	
189	758	(768)*	777	
190	791		810	(819)**
192	821		840	
194	859		878	
195	884		903	
196	908		927	
198	934		953	
199	958	(968)*	977	
200	980		999	

Interval	US Presentation (1 second)
160	206
180	581
189	768
191	819
199	968

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 5 Tape 8

Interval	Begin CS	Duration of CS	End CS	
201	3		22	
202	29		48	
204	61		80	
206	99		118	
207	127		146	
209	151		170	
210	174		193	
211	201	(217)*	220	
213	235		254	
215	277		296	
217	317		336	
219	356		375	
220	379		398	
222	415	(426,430)*	434	
223	437		456	
224	459		478	
225	482		501	
226	505		524	(526)**
228	532		551	
229	563	(572)*	582	
231	596		615	
233	631		650	
234	655		674	
236	694		713	
237	729		748	
239	756		775	
240	783		802	
242	822		841	
243	848		867	
245	888		907	
247	917		936	
248	942		961	
250	971		990	

Interval	US Presentation (1 second)
211	217
222	426
222	430
227	526
229	572

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 6 Tape 5

Interval	Duration of CS: Begin CS		End CS	
251	1		20	
253	25	(44)*	44	
254	58		77	
255	85		104	
256	107		126	
258	132		151	
259	154		173	
260	183		202	
261	206		225	(228)**
263	249		268	
266	295		314	
267	329		348	
269	354		373	
270	379		398	
271	406		425	
273	439		458	
275	474		493	
276	505		524	
278	547		566	
280	573		592	
281	595		614	
282	618		637	
284	652		671	
286	702		721	
288	731		750	
289	760		779	
290	787		806	
291	810		829	(848)**
294	852	(860)*	871	
295	878		897	
296	906		925	(949)**
299	952		971	
300	977		996	

Interval	US Presentation (1 second)
253	44
262	228
293	848
294	860
298	949

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 7 Tape 11

Interval	Begin CS	Duration of CS	End CS	
301	2		21	
303	31		50	
304	54		73	
305	83	(93)*	102	
306	106		125	
307	129		148	
308	158		177	(188,192)**
311	196		215	
312	220		239	
313	248		267	
315	286		305	
316	308		327	
318	333		352	
319	356		375	
320	379		398	
321	401		420	
323	437		456	
325	475	(483)*	494	
326	507	(520)*	526	
328	537		556	
329	568		587	
331	594		613	
332	628		647	
333	650		669	
335	672		691	
336	695		714	
337	717		736	
338	744		763	
340	781		800	
342	825		844	
345	875		894	
347	911		930	
349	954		973	

Interval	US Presentation (1 second)
305	93
309	188
310	192
325	483
326	520

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 8 Tape 6

Interval	Begin CS	Duration of CS	End CS	
352	11		30	(38)**
354	46		65	
355	77		96	
356	107		126	
358	131		150	
359	156		175	
360	180		199	
362	219		238	
364	256		275	
365	281		300	
367	315		334	
368	339		358	
370	374	(389)*	393	
371	397		416	
373	441	(456)*	460	
374	465		484	
375	487		506	
377	517		536	
378	542		561	
379	565	(583)*	584	
381	599		618	
383	646		665	
384	670		689	
386	697		716	
387	722		741	
388	745		764	
390	783		802	
391	807		826	
393	845		864	
395	878		897	
396	907		926	
398	942	(947)*	961	
400	972		991	

Interval	US Presentation (1 second)
353	38
370	389
373	456
380	583
398	947

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 9 Tape 9

Interval	Duration of CS: Begin CS		End CS	
401	1		20	
402	30		49	
404	60		79	
405	87		106	
407	117		136	
409	158		177	
410	180		199	
411	209		228	
413	237		256	
414	260		279	
416	296		315	
418	337		356	(370)**
420	376		395	
421	410		429	
424	451		470	
425	478		497	
426	500		519	
427	522		541	
428	544		563	
429	566	(570)*	585	
431	596		615	
433	639		658	
435	676		695	
436	698		717	
437	728		747	
439	758		777	(797)**
441	801		820	
443	835		854	
444	864	(868)*	883	
445	886		905	
447	924	(931)*	943	
448	947		966	
449	969		988	

Interval	US Presentation (1 second)
419	370
429	570
440	797
444	868
447	931

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 10 Tape 10

Interval	Duration of CS Begin CS		End CS	
451	10		29	
454	54		73	
455	81		100	(111)**
457	123		142	
460	179		198	
461	205		224	
463	236		255	
464	259	(271)*	278	
465	282		301	
466	309		328	
468	348		367	
470	384		403	
472	414		433	
473	438		457	
474	463		482	
476	494		513	
477	526		545	
479	564		583	
481	595		614	
482	628		697	
483	650		669	
485	679	(682)*	698	
486	703		722	
488	744		763	
489	770		789	
491	799		818	
493	833		852	
494	861		880	
495	887	(889,904)*	906	
496	910		929	
498	936		955	
499	958		977	
500	980		999	

Interval	US Presentation (1 second)
456	111
464	271
485	682
495	889
495	904

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 11 Tape 7

Interval	Duration of CS Begin CS		End CS	
501	2		21	
503	31		50	
504	54		73	
505	83	(93)*	102	
506	106		125	
507	129		148	
508	158		177	(188,192)**
511	196		215	
512	220		239	
513	248		267	
515	286		305	
516	308		327	
518	333		352	
519	356		375	
520	379		398	
521	401		420	
523	437		456	
525	475	(483)*	494	
526	507	(520)*	526	
528	537		556	
529	568		587	
531	594		613	
532	628		647	
533	650		669	
535	672		691	
536	695		714	
537	717		736	
538	744		763	
540	781		800	
542	825		844	
545	875		894	
547	911		930	
549	954		973	

Interval	US Presentation (1 second)
505	93
509	188
510	192
525	483
527	520

* US presentation constituting a CS-US pairing.
** US presented alone.

Day 12 Tape 12

Interval	Duration of CS: Begin CS		End CS	
552	12	(19)*	31	(11)**
553	39		58	
554	65		84	
556	105		124	
557	130		149	(152)**
559	153	(156)*	172	
561	195		214	
563	231		250	
564	259		278	
565	282		301	
566	304		323	
567	330		349	
569	352		371	
570	389		408	
572	411		430	
573	444		463	
575	474		493	
576	501	(511)*	520	
577	523		542	
579	556		575	
580	578		597	
581	608		627	
583	646		665	
584	669		688	
586	696		715	
587	718		737	
588	741		760	
590	774		793	
592	814		833	
594	862		881	
595	886		905	
597	927		946	
599	957		976	

Interval	US Presentation (1 second)
551	11
552	19
558	152
559	156
576	511

* US presentation constituting a CS-US pairing.
** US presented alone.

Appendix N

LIST OF ACTUAL CSs ALONE, USs ALONE AND PAIRING SEQUENCES USED IN EXPERIMENT 1 AND 2

NOTE

Experiment 1 contains Groups 2, 6, 12 and 36. Group 2 received the first two tapes; Group 6 the first 6; Group 12 received all the tapes, and Group 36 received all 12 tapes three times in the order listed.

In Experiment 2 Group 2 received the first two tapes, while Group 2+PCUT received all 12 tapes three times in the order listed. The remaining groups in Experiment 2 received variations of these tapes as described in the text.

GROUP 2

NCS 60 NUS 3 NP 7 NINT 100

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
USS	17	53	56							
PAIRINGS	1	6	7	43	59	70	70			

Note: This sequence was presented once to Group 2 in Experiment 1 and also to Group 2 in Experiment 2.

GROUP 6

NCS 180 NUS 10 NP 20 NINT 300

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
CSS	102	104	105	106	108	109	110	113	117	118
CSS	121	122	124	125	127	129	130	132	133	135
CSS	136	138	139	141	142	144	145	146	147	149
CSS	152	154	155	157	158	162	163	165	167	168
CSS	170	171	172	173	175	177	179	182	183	185
CSS	186	187	190	192	194	195	196	198	200	201
CSS	202	204	206	207	209	210	213	215	217	219
CSS	220	223	224	225	226	228	231	233	234	236
CSS	237	239	240	242	243	245	247	248	250	251
CSS	254	255	256	258	259	260	261	263	266	267
CSS	269	270	271	273	275	276	278	280	281	282
CSS	284	286	288	289	290	291	295	296	299	300
USS	17	53	56	123	150	191	227	262	293	298
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	253	294

Note: This sequence was presented once to Group 6 in Experiment 1.

GROUP 12

NCS 359 NUS 20 NP 40 NINT 600

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
CSS	102	104	105	106	108	109	110	113	117	118
CSS	121	122	124	125	127	129	130	132	133	135
CSS	136	138	139	141	142	144	145	146	147	149
CSS	152	154	155	157	158	162	163	165	167	168
CSS	170	171	172	173	175	177	179	182	183	185
CSS	186	187	190	192	194	195	196	198	200	201
CSS	202	204	206	207	209	210	213	215	217	219
CSS	220	223	224	225	226	228	231	233	234	236
CSS	237	239	240	242	243	245	247	248	250	251
CSS	254	255	256	258	259	260	261	263	266	267
CSS	269	270	271	273	275	276	278	280	281	282
CSS	284	286	288	289	290	291	295	296	299	300
CSS	301	303	304	306	307	308	311	312	313	315
CSS	316	318	319	320	321	323	328	329	331	332
CSS	333	335	336	337	338	340	342	345	347	349
CSS	352	354	355	356	358	359	360	362	364	365
CSS	367	368	371	374	375	377	378	381	383	384
CSS	386	387	388	390	391	393	395	396	400	401
CSS	402	404	405	407	409	410	411	413	414	416
CSS	418	420	421	424	425	426	427	428	431	433
CSS	435	436	437	439	441	443	445	448	449	451
CSS	454	455	457	460	461	463	465	466	468	470
CSS	472	473	474	476	477	479	481	482	483	486
CSS	488	489	491	493	494	496	498	499	500	501
CSS	503	504	506	507	508	511	512	513	515	516
CSS	518	519	520	521	523	528	529	531	532	533
CSS	535	536	537	538	540	542	545	547	549	553
CSS	554	556	557	561	563	564	565	566	567	569
CSS	570	572	573	575	577	579	580	581	583	584
CSS	586	587	588	590	592	594	595	597	599	
USS	17	53	56	123	150	191	227	262	293	298
USS	309	310	353	419	440	456	509	510	551	558
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	253	294
PAIRINGS	305	325	326	370	373	379	398	429	444	447
PAIRINGS	464	485	495	495	505	525	526	552	559	576

<u>Note</u>: This sequence was presented once to Group 12 in Experiment 1.

GROUP 36

NCS 359 NUS 20 NP 40 NINT 600

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
CSS	102	104	105	106	108	109	110	113	117	118
CSS	121	122	124	125	127	129	130	132	133	135
CSS	136	138	139	141	142	144	145	146	147	149
CSS	152	154	155	157	158	162	163	165	167	168
CSS	170	171	172	173	175	177	179	182	183	185
CSS	186	187	190	192	194	195	196	198	200	201
CSS	202	204	206	207	209	210	213	215	217	219
CSS	220	223	224	225	226	228	231	233	234	236
CSS	237	239	240	242	243	245	247	248	250	251
CSS	254	255	256	258	259	260	261	263	266	267
CSS	269	270	271	273	275	276	278	280	281	282
CSS	284	286	288	289	290	291	295	296	299	300
CSS	301	303	304	306	307	308	311	312	313	315
CSS	316	318	319	320	321	323	328	329	331	332
CSS	333	335	336	337	338	340	342	345	347	349
CSS	352	354	355	356	358	359	360	362	364	365
CSS	367	368	371	374	375	377	378	381	383	384
CSS	386	387	388	390	391	393	395	396	400	401
CSS	402	404	405	407	409	410	411	413	414	416
CSS	418	420	421	424	425	426	427	428	431	433
CSS	435	436	437	439	441	443	445	448	449	451
CSS	454	455	457	460	461	463	465	466	468	470
CSS	472	473	474	476	477	479	481	482	483	486
CSS	488	489	491	493	494	496	498	499	500	501
CSS	503	504	506	507	508	511	512	513	515	516
CSS	518	519	520	521	523	528	529	531	532	533
CSS	535	536	537	538	540	542	545	547	549	553
CSS	554	556	557	561	563	564	565	566	567	569
CSS	570	572	573	575	577	579	580	581	583	584
CSS	586	587	588	590	592	594	595	597	599	
USS	17	53	56	123	150	191	227	262	293	298
USS	309	310	353	419	440	456	509	510	551	558
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	253	294
PAIRINGS	305	325	326	370	373	379	398	429	444	447
PAIRINGS	464	485	495	495	505	525	526	552	559	576

<u>Note</u>: This sequence was presented three times to Group 36 in Experiment 1 and to Group 2+PCUT in Experiment 2.

GROUP 2+PCUT

NCS 359 NUS 20 NP 40 NINT 600

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
CSS	102	104	105	106	108	109	110	113	117	118
CSS	121	122	124	125	127	129	130	132	133	135
CSS	136	138	139	141	142	144	145	146	147	149
CSS	152	154	155	157	158	162	163	165	167	168
CSS	170	171	172	173	175	177	179	182	183	185
CSS	186	187	190	192	194	195	196	198	200	201
CSS	202	204	206	207	209	210	213	215	217	219
CSS	220	223	224	225	226	228	231	233	234	236
CSS	237	239	240	242	243	245	247	248	250	251
CSS	254	255	256	258	259	260	261	263	266	267
CSS	269	270	271	273	275	276	278	280	281	282
CSS	284	286	288	289	290	291	295	296	299	300
CSS	301	303	304	306	307	308	311	312	313	315
CSS	316	318	319	320	321	323	328	329	331	332
CSS	333	335	336	337	338	340	342	345	347	349
CSS	352	354	355	356	358	359	360	362	364	365
CSS	367	368	371	374	375	377	378	381	383	384
CSS	386	387	388	390	391	393	395	396	400	401
CSS	402	404	405	407	409	410	411	413	414	416
CSS	418	420	421	424	425	426	427	428	431	433
CSS	435	436	437	439	441	443	445	448	449	451
CSS	454	455	457	460	461	463	465	466	468	470
CSS	472	473	474	476	477	479	481	482	483	486
CSS	488	489	491	493	494	496	498	499	500	501
CSS	503	504	506	507	508	511	512	513	515	516
CSS	518	519	520	521	523	528	529	531	532	533
CSS	535	536	537	538	540	542	545	547	549	553
CSS	554	556	557	561	563	564	565	566	567	569
CSS	570	572	573	575	577	579	580	581	583	584
CSS	586	587	588	590	592	594	595	597	599	
USS	17	53	56	123	150	191	227	262	293	298
USS	309	310	353	419	440	456	509	510	551	558
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	253	294
PAIRINGS	305	325	326	370	373	379	398	429	444	447
PAIRINGS	464	485	495	495	505	525	526	552	559	576

Note: This sequence was presented three times to Group 2+PCUT in Experiment 2 and to Group 36 in Experiment 1.

GROUP 2+PCT

NCS 359 NUS 3 NP 40 NINT 600

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
CSS	102	104	105	106	108	109	110	113	117	118
CSS	121	122	124	125	127	129	130	132	133	135
CSS	136	138	139	141	142	144	145	146	147	149
CSS	152	154	155	157	158	162	163	165	167	168
CSS	170	171	172	173	175	177	179	182	183	185
CSS	186	187	190	192	194	195	196	198	200	201
CSS	202	204	206	207	209	210	213	215	217	219
CSS	220	223	224	225	226	228	231	233	234	236
CSS	237	239	240	242	243	245	247	248	250	251
CSS	254	255	256	258	259	260	261	263	266	267
CSS	269	270	271	273	275	276	278	280	281	282
CSS	284	286	288	289	290	291	295	296	299	300
CSS	301	303	304	306	307	308	311	312	313	315
CSS	316	318	319	320	321	323	328	329	331	332
CSS	333	335	336	337	338	340	342	345	347	349
CSS	352	354	355	356	358	359	360	362	364	365
CSS	367	368	371	374	375	377	378	381	383	384
CSS	386	387	388	390	391	393	395	396	400	401
CSS	402	404	405	407	409	410	411	413	414	416
CSS	418	420	421	424	425	426	427	428	431	433
CSS	435	436	437	439	441	443	445	448	449	451
CSS	454	455	457	460	461	463	465	466	468	470
CSS	472	473	474	476	477	479	481	482	483	486
CSS	488	489	491	493	494	496	498	499	500	501
CSS	503	504	506	507	508	511	512	513	515	516
CSS	518	519	520	521	523	528	529	531	532	533
CSS	535	536	537	538	540	542	545	547	549	553
CSS	554	556	557	561	563	564	565	566	567	569
CSS	570	572	573	575	577	579	580	581	583	584
CSS	586	587	588	590	592	594	595	597	599	
USS	17	53	56							
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	253	294
PAIRINGS	305	325	326	370	373	379	398	429	444	447
PAIRINGS	464	485	495	495	505	525	526	552	559	576

Note: This sequence was repeated two more times for Group 2+PCT except that all USs alone were omitted.

GROUP 2+PUT

NCS 60 NUS 20 NP 40 NINT 600

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
USS	17	53	56	123	150	191	227	262	293	298
USS	309	310	353	419	440	456	509	510	551	558
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	235	294
PAIRINGS	305	325	326	370	373	379	398	429	444	447
PAIRINGS	464	485	495	495	505	525	526	552	559	576

<u>Note</u>: In Experiment 2 this sequence was presented once to Group 2+PUT and was repeated two more times omitting all CSs alone

GROUP 2+PT

NCS 60 NUS 3 NP 40 NINT 600

CSS	3	4	9	11	12	13	14	16	18	20
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	60	62	63	65	66	67
CSS	68	69	72	74	76	77	78	80	81	82
CSS	84	85	88	89	90	92	94	96	98	99
USS	17	53	56							
PAIRINGS	1	6	7	43	59	70	70	112	115	120
PAIRINGS	160	180	189	199	211	222	222	229	235	294
PAIRINGS	305	325	326	370	373	379	398	429	444	447
PAIRINGS	464	485	495	495	505	525	526	552	559	576

<u>Note</u>: In Experiment 2 this sequence was presented once to Group 2+PT and was repeated two more times omitting all CSs and USs presented alone.

GROUP 2+T

NCS 6Ø NUS 3 NP 7 NINT 1ØØ

CSS	3	4	9	11	12	13	14	16	18	2Ø
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	6Ø	62	63	65	66	67
CSS	68	69	72	74	76	77	78	8Ø	81	82
CSS	84	85	88	89	9Ø	92	94	96	98	99
USS	17	53	56							
PAIRINGS	1	6	7	43	59	7Ø	7Ø			

Note: In Experiment 2 this sequence was presented once to Group 2+T. The remsining time(34 days), the animals were exposed only to apparatus cues.

GROUP 2

NCS 6Ø NUS 3 NP 7 NINT 6ØØ

CSS	3	4	9	11	12	13	14	16	18	2Ø
CSS	22	23	24	25	27	28	29	31	32	33
CSS	36	37	38	39	42	45	47	48	49	51
CSS	52	54	55	57	6Ø	62	63	65	66	67
CSS	68	69	72	74	76	77	78	8Ø	81	82
CSS	84	85	88	89	9Ø	92	94	96	98	99
USS	17	53	56							
PAIRINGS	1	6	7	43	59	7Ø	7Ø			

Note: This sequence was presented once to both Group 2 in Experiment 2 and Group 2 in Experiment 1.

Appendix O

STATISTICAL ANALYSES PERFORMED IN EXPERIMENT 1

Explanation of Abbreviations and Symbols in the Tables

Symbol		Explanation
SV	--------------------	Source of Variance
DF	--------------------	Degrees of Freedom
MS	--------------------	Mean Square
*	--------------------	$p < .05$
**	--------------------	$p < .01$
***	--------------------	$p < .001$
****	--------------------	$p = .02$
*****	--------------------	$p > .002$
G	--------------------	Group Effect
T	--------------------	Trial Effect
S	--------------------	Subject
S(G)	--------------------	The between group error term
ST(G)	--------------------	The within group error term

Table A

Analysis of variance on Suppression Ratios for Post-test Sessions in Experiment 1.

SV	DF	MS	F
G	3	0.9260	6.9467 **
T	5	0.0686	5.0814 **
S(G)	20	0.1333	
GT	15	0.0315	2.3333 *
ST(G)	100	0.0135	

Table B

Analysis of variance on Response Rates for Pre-test Sessions in Experiment 1.

SV	DF	MS	F
G	3	0.0078	1.392
T	2	0.0375	6.040 **
S(G)	20	0.0056	
GT	06	0.0076	1.2258
ST(G)	40	0.0062	

Table C

Analysis of variance on Response Rates for Post-test Sessions in Experiment 1.

SV	DF	MS	F
G	3	127.0255	1.4970
T	5	42.5458	2.3667
S(G)	20	121.0097	
GT	15	35.8532	1.9944
ST(G)	100	17.9764	

Table D

Individual t-tests (two-tailed) performed on Group suppression Ratios for Post-test sessions in Experiment 1.

Group	df	t-value
2 vs 36	20	4.371***
2 vs 12	20	1.213
2 vs 6	20	2.406*
6 vs 36	20	1.965
6 vs 12	20	1.194
12 vs 36	20	3.159**

Appendix P

STATISTICAL ANALYSES PERFORMED IN EXPERIMENT 2

NOTE

Experiment 2 contains a group with a population of (N=12) and groups with a population of (N=6). It was therefore necessary to perform an unequal (N) analysis of Variance in Experiment 2.

Table E

Analysis of Variance on Pre-CS Response rates for groups in Experiment 2

SV	DF	MS	F
Total	41		
G	5	23.32	.617
S(G)	36	14.39	

Table F

Analysis of Variance on Pre-test Suppression ratios in Experiment 2.

SV	DF	MS	F
Total	41		
G	5	0.1092	3.184
S(G)	36	0.0348	

Table G

Analysis of Variance Performed on Suppression Scores for Overall Post-test Sessions in Experiment 2.

SV	DF	MS	F
Total	41		
G	5	.0890	4.73 *****
S(G)	36	.0188	

Table H

Individual t-tests (two-tailed) Performed on Group Suppression Ratios for Post-test Sessions in Experiment 2.

Group	df	t-Value
2 Vs 2+PCUT	36	2.53****
2 Vs 2+PCT	36	.087
2 Vs 2+PUT	36	.087
2 Vs PT	36	.667
2 Vs T	36	3.62****

Appendix Q

STATISTICAL ANALYSES PERFORMED IN EXPERIMENT 3

Table I

Analysis of Variance on Group Mean Suppression Ratios in Experiment 3

SV	DF	MS	F
G	4	0.1702	3.64 ***
T	1	0.0184	0.0393
S(G)	25	0.0468	
GT	4	0.0317	1.3964
ST(G)	25	0.0227	

Table J

A t-test (two-tailed) performed on Group Mean Suppression Ratios for Group 2+T between Experiment 2 and 3.

Group	DF	t-value
Group 2+T (Expt. 2)		
Vs	25	3.22 **
Group 2+T (Expt.3)		

Appendix R

COMPUTER PROGRAM TO FIND MATHEMATICAL VALUE FOR RESCORLA-WAGNER MODEL

PROGRAM STEPIT 07/16/73 1610

```
2300 SUBROUTINE STEPIT(FUNK)
2305 COMMON OB(20),NX,TH(20),
2307C NV,NTRACE,MATRIX,CHISQ,MASK(5),X(5),XMAX(5),
2308C XMIN(5),DELTAX(5),DELMIN(5),ERR(5,15),JVARY
2310 DIMENSION VEC(5),TRIAL(5),XSAVE(5),CHI(5),DX(5),SECOND(2,2),
2311C OLDVEC(5),SALVO(5),XOSC(5,15),CHIOSC(15)
2312 EXTERNAL FUNK
2313 KW = 61
2314 NVMAX=5
2315 MOSQUE = 15
2316↑ RATIO=10.0
2317↑ COLIN=0.99
2318↑ NCOMP=5
2319↑ ACK=2.0
2320↑ SIGNIF=2.E8
2321↑210 FORMAT(* ENTERING SUBROUTINE STEPIT...COPYRIGHT 1965*
2322C*...J.P.CHANDLER,*/* INDIANA UNIV,....INITIAL VALUES ARE;*/
2323C*      MASK           X              XMAX              XMIN*/
2324C(4(4X,E12.4)))
2325↑ HUGE=1.E307
2335↑ JVARY=0
2360↑40 IF(NV)290,290,50
2365↑50 NACTIV=0
2370↑ DO 150 I=1,NV
2375↑ IF(MASK(I))150,60,150
2380↑60 IF(SIGNIF*ABSF(DELTAX(I))-ABSF(X(I)))70,70,100
2385↑70 IF(X(I))90,80,90
2390↑80 DELTAX(I)=0.01
2395↑ GO TO 100
2400↑90 DELTAX(I)=0.01*X(I)
2405↑100 IF(DELMIN(I))120,110,120
2410↑110 DELMIN(I)=DELTAX(I)/SIGNIF
2415↑120 IF(XMAX(I)-XMIN(I))130,130,140
2420↑130 XMAX(I)=HUGE
2425↑ XMIN(I)=-HUGE
2430↑140 NACTIV=NACTIV+1
2435 X(I) = MAX1F(XMIN(I),MIN1F(XMAX(I),X(I)))
2440↑150 CONTINUE
2445↑ COMPAR=0.0
2450↑ IF(NACTIV-1)160,190,180
2455↑160 DO 170 J=1,NV
2460↑170 MASK(J)=0
2465↑ GO TO 50
2470↑180 A=NACTIV
2475↑ SUB=2.0/(A-1.0)
2480↑ P=2.0*(1.0/SQRTF(A)/(1.0-0.5**SUB)-1.0)
2485 COMPAR = MIN1F(.999,ABSF((1.-(1.-COLIN)**SUB)*(1.+P*(1.-COLIN))))
2490↑190 IF(NTRACE)230,200,200
2495↑200 PRINT 210,(MASK(J),X(J),XMAX(J),XMIN(J),J=1,NV)
2550↑ WRITE OUTPUT TAPE KW,260,(DELTAX(J),J=1,NV)
2555↑260 FORMAT(* DELTAX=*,E12.4,/,3X,E12.4,/,3X,E12.4,/,3X,
```

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```
CE12.4)
↑ WRITE OUTPUT TAPE KW,270L(DELMIN(J),J=1,NV)
↑270 FORMAT(* DELMIN=*,5E12.4,/,8X,5E12.4,/,8X,E12.4,/,8X
C5E12.4)
↑230 CALL FUNK
↑ NF=1
↑ JOCK=1
↑290 IF (NTRACE) 320,300,300
↑300 WRITE OUTPUT TAPE KW,310,NV,NACTIV,MATRIX,NCOMP,RATIO,
CACK,COLIN,COMPAR,CHISQ
↑310 FORMAT(//,I3,* VARIABLES*,I4, * ACTIVE.*,/
C* MATRIX = *,I4,* NCOMP = *,I4,/,* RATIO = *,F5.1,
C* NACK = *,F5.1,* COLIN = *,F6.3,/,* COMPAR = *,F6.3,
C* CHISQ = *, E15.8)
↑320 IF(NV)2150,2150,330
↑330 IF(NTRACE)360,360,340
↑340 WRITE OUTPUT TAPE KW,350
↑350 FORMAT(//,*TRACE OF MAP OF MIN PROGR*)
↑360 DO 370 I=1,NV
↑ DX(I)=DELTAX(I)
↑ VEC(I)=0.
↑ DO 370 J=1,NV
↑370 ERR(I,J)=0.
↑ CHIOLD=CHISQ
↑ NOSC=0
↑380 NCIRC=0
↑ NZIP=0
*MAIN DO LOOP FOR CYCLING THROUGH THE VARIABLES
*FIRST TRAIL STEP WITH EACH VARIABLE IS SEPERATE.
↑390 NACK=0
↑ DO 1350 I=1,NV
↑ OLDVEC(I)=VEC(I)
↑ VEC(I)=0.0
↑ TRIAL(I)=0.0
↑ IF(MASK(I))400,410,400
↑400 VEC(I)=-0.0
↑ GO TO 1350
↑410 NACK=NACK+1
↑ SAVE=X(I)
↑ IF(SIGNIF*ABSF(DX(I))-ABSF(X(I)))530L530L420
↑420 X(I)=SAVE+DX(I)
↑ JVARY=0
↑ IF(JOCK)440,440,430
↑430 JOCK=0
↑ JVARY=I
↑440 NFLAG=1
↑ IF(X(I)-XMIN(I))460,4U0,4U0
↑450 IF(X(I)-XMAX(I))T70,470,460
↑460 NFLAG=NFLAG+3
↑ GO TO 490
↑470 CALL FUNK
```

```
 NF=NF+1
 JVARY=I
 CHIME=CHISQ
 IF(CHISQ-CHIOLD)620,480,490
480 NFLAG=NFLAG+1
490 X(I)=SAVE-DX(I)
 IF(X(I)-XMIN(I))590,500,500
500 IF(X(I)-XMAX(I))510,510,590
510 CALL FUNK
 NF=NF+1
 JVARY=I0
 IF(CHISQ-CHIOLD)610LU20,550
520 NFLAC=NFLAG+1
530 IF(NFLAG-S)540,5X0,590
540 IF((CHISQ-CHIME)*(CHIMEM2.*CHIOLD+CHISQ))5U0,590,550
550 TRIAL(I)=.5*DX(I)*(CHISQMCHIME)/(CHIME-2.*CHIOLD+CHISQ)
 VEC(I)=TRIAL(I)/ABSF(DX(I))
 X(I)=SAVEKTRIAL(I)
 CALL FUNK
 NF=NF+1
 IF(CHISQ-CHIOLD)560,570,570
560 CHIOLD=CHISQ
 JOCK=1
 GO TO 600
570 TRIAL(I)=0.0
 VEC(I)=0.0
 GO TO 590
580 VEC(I) = -2.0
590 X(I)=SAVE
600 NCIRC=NCIRC+1
 IF(NCIRC-NACTIV)690,1430,1430
610 DX(I)=-DX(I)
* A LOWER VALUE HAS BEEN FOUND. HENCE THIS VARIABLE WILL CHANGE
620 NCIRC=0
 DEL=DX(I)
630 CHIME=CHIOLD
 CHIOLD=CHISQ
 VEC(I)=VEC(I)+DEL/ABSF(DX(I))
 TRIAL(I)=TRIAL(I)+DEL
 DEL=ACK*DEL
 SAVE=X(I)
 X(I)=SAVE+DEL
 IF(X(I)-XMIN(I))630,640,640
640 IF(X(I)-XMAX(I))650,650,680
650 CALL FUNK
 NF=NF+1
 IF(CHISQ-CHIOLD)630,660,660
660 CINDER=(0.5/ACK)*(ACK**2*CHIME-(ACKJ*2-1.0)*CHIOLL-
CCHISQ)/(ACK*CHIME-(ACK+1.0)*CHIOLD+CHISQ)
 X(I)=SAVE+CINDER*DEL
 CALL FUNK
```

```
 NF=NF+1
 IF(CHISQ-CHIOLD)670,680,680
670 CHIOLD=CHISQ
 TRIAL(I)=TRIAL(I)+CINDER*DEL
 VEC(I)=VEC(I)+CINDER*DEL/ABSF(DX(I))
 GO TO 690
680 X(I)=SAVE
690 IF(NZIP-1)1340,700,700
700 IF(ABSF(VEC(I))-ACK)750,710,710
710 DX(I)=ACK*ABSF(DX(I))
 VEC(I)=VEC(I)/ACK
 OLDVEC(I)=OLDVEC(I)/ACK
 DO 720 J=1,MOSQUE
720 ERR(I,J)=ERR(I,J)/ACK
 IF(NTRACE)750,750,730
730 WRITE OUTPUT TAPE KW,740,I,DX(I)
740 FORMAT(* STEP SIZE *,I3,* INCREASED TO * E12.5)
750 SUMO=0.0
 SUMV=0.0
 DO 760 J=1,NV
 SUMO=SUMO+OLDVEC(J)**2
760 SUMV=SUMV+VEC(J)**2
 IF(SUMO*SUMV)1340,1340,770
770 SUMO=SQRTF(SUMO)
 SUMV=SQRTF(SUMV)
 COSINE=0.0
 DO 780 J=1,NV
780 COSINE=COSINE+(OLDVEC(J)/SUMO)*(VEC(J)/SUMV)
 IF(NZIP-1)1340,790,800
790 IF(NACK-NACTIV)1340,820,820
800 IF(NACK-NACTIV)820,810,810
810 IF(NZIP-NCOMP)820,830,830
820 IF(COSINE-COMPAR)1340,830,830
* SIMON SAYS TAKE AS MANY GIANT STEPS AS POSSIBLE
830 IF(NTRACE)860,860,840
840 WRITE OUTPUT TAPE KW,850,CHIOLD,(VEC(J),J=1,I)
850 FORMAT(* CHISQ =*,E15.3,* NO. OF STEPS =*,/,
C5X,5F9.2,/,5X,5F9.2,/,5X,5F9.2,/5X,5F9.2)
860 NGIANT=0
 NTRY=0
 NRETRY=0
 KL=1
 NOSC=NOSC+1
 IF(NOSC-MOSQUE)890,890,870
870 NOSC=MOSQUE
 DO 880 K=2,MOSQUE
 CHIOSC(K-1)=CHIOSC(K)
 DO 880 J=1,NV
 XOSC(J,K-1)=XOSC(J,K)
880 ERR(J,K-1)=ERR(J,K)
890 DO 900 J=1,NV
```

```
 XOSC(J,NOSC)=X(J)
900 ERR(J,NOSC)=VEC(J)/SUMV
 CHIOSC(NOSC)=CHIOLD
 IF(NOSC-3)960,910,910
* SEARCH FOR A PREVIOUS SUCCESSFUL GIANT STEP IN A DIRECTION
* MORE NEARLY PARALLEL TO THE DIRECTION OF THE PROPOSED
* STEP THAN WAS THE IMMEDIATELY PREVIOUS ONE.
910 COXCOM=0.0
 DO 920 J=1,NV
920 COXCOM=COXCOM+ERR(J,NOSC)*ERR(J,NOSC-1)
 NAH=NOSC-2
930 NTRY = 0
 DO 950 K=KL,NAH
 NRETRY=NAH-K
 COSINE=0.0
 DO 940 J = 1, NV
940 COSINE=COSINE+ERR(J,NOSC)*ERR(J,K)
 IF(COSINE-COXCOM)950,950,970
950 CONTINUE
960 CHIBAK=CHI(I)
 GO TO 1020
970 NTRY=1
 KL=K+1
 IF(NTRACE)1000,1000,980
980 NT=NOSC-K
 WRITE OUTPUT TAPE KW,990,NT
990 FORMAT(* -POS OSC PER*I3,*DET*)
1000 DO 1010 J=1,NV
 SALVO(J)=TRIAL(J)
1010 TRIAL(J)=(X(J)-XOSC(J,K))/ACK
 CHIBAK=CHIOLD+(CHIOSC(K)-CHIOLD)/ACK
1020 DO 1040 J=1,NV
 XSAVE(J)=X(J)
 TRIAL(J)=ACK*TRIAL(J)
 IF(MASK(J))1040,1030,1040
1030 X(J)=MAX1F(MIN1F(X(J)+TRIAL(J),XMAX(J)),XMIN(J))
1040 CONTINUE
 JOCK=0
 JVARY=0
 CALL FUNK
 NF=NF+1
 IF(CHISQ-CHIOLD)1050,1080,1080
1050 CHIBAK=CHIOLD
 CHIOLD=CHISQ
 NGIANT=NGIANT+1
 IF(NTRACE)1020,1020,1060
1060 PRINT 1070,CHISQ,(X(J),J=1,NV)
1070 FORMAT(* CHISQ =*,E15.3,/,*X(I) =*,2X,5E12.5,/,
C5E12.5)
 GO TO 1020
1080 IF(NRETRY)1100,1100,1090
```

```
1090 IF(NGIANT)1150,1150,1100
1100 CINDER=(.5/ACK)*(ACK**2*CHIBAK-(ACK**2-1.0)*CHIOLD-CHISQ)/
C(ACK*CHIBAK-(ACK+1.0)*CHIOLD+CHISQ)
 DO 1120 J=1,NV
 IF(MASK(J))1120,1110,1120
1110 X(J)=MAX1F(MIN1F(XSAVE(J)+CINDER*TRIAL(J),XMAX(J)),XMIN(J))
1120 CONTINUE
 JOCK=0
 JVARY=0
 CALL FUNK
 NF=NF+1
 IF(CHISQ-CHIOLD)1280,1130,1130
1130 IF(NGIANT)1170,1140,1170
1140 IF(NTRY)1150,1170,1150
1150 DO 1160 J=1,NV
 TRIAL(J)=SALVO(J)
1160 X(J)=XSAVE(J)
 GO TO 1190
1170 DO 1180 J=1,NV
 TRIAL(J)=TRIAL(J)/ACK
1180 X(J)=XSAVE(J)
1190 IF(NTRACE)1240,1240,1200
1200 WRITE OUTPUT TAPE KW,1210,CHIOLD,NGIANT
1210 FORMAT(* CHISQ = *,E15.8,*  AFTER* I3,* GIANT STEPS*)
 WRITE OUTPUT TAPE KW,1220,(X(J),J=1,NV)
1220 FORMAT(* X(I) =*,5E12.5,/,5E12.5)
 WRITE OUTPUT TAPE KW,1230
1230 FORMAT(/)
1240 IF(NGIANT)1250,1250,1310
1250 IF(NRETRY)1260,1260,930
1260 IF(NTRY)1270,1330,1270
1270 NTRY=0
 GO TO 960
1280 CHIOLD=CHISQ
 JOCK=1
 IF(NTRACE)1310,1310,1290
1290 STEPS=FLOATF(NGIANT)+CINDER
 PRINT 1300,CHIOLD,STEPS
1300 FORMAT(/8H CHISQ =E15.8,7H  AFTERF6.1,13H GIANT STEPS.)
 WRITE OUTPUT TAPE KW,1220,(X(J),J=1,NV)
 WRITE OUTPUT TAPE KW,1230
1310 IF(NTRY)1320,330,1320
1320 NOSC=0
 GO TO 380
1330 NOSC=XMAX0F(NOSC-1,0)
1340 CHI(I)=CHIOLD
1350 CONTINUE
* ANOTHER CYCLE THROUGH THREE VARIABLES HAS BEEN COMPLETED.
* PRINT ANOTHER LINE OF TRACES
 IF(NTRACE)1370,1370,1360
1360 WRITE OUTPUT TAPE KW,850,CHIOLD,(VEC(J),J=1,NV)
```

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```
 1370 CONTINUE
 1380 IF(NZIP)1420,1390,1420
 1390 IF(NTRACE)1420,1420,1400
 1400 PRINT 1220,(X(J),J=1,NV)
 1420 NZIP=NZIP+1
 GO TO 390
* A MINIMUM HAS BEEN FOUND, PRINT THE REMAINING TRACES.
 1430 IF(NTRACE)1450,1450,1440
 1440 WRITE OUTPUT TAPE KW,350,CHIOLD,(VEC(J),J=1,I)
 1450 IF(NTRACE)1470,1470,1460
 1460 WRITE OUTPUT TAPE KW,1220,(X(J),J=1,NV)
 PRINT 1230
 1470 CONTINUE
* DECREASE THE SIZE OF THE STEPS FOR ALL VARIABLES
 1480 NOSC=0
 NGATE=1
 DO 1520 J=1,NV
 IF(MASK(J))1520,1490,1520
 1490 IF(MAX1F(VEC(J),SIGNF(1.0,VEC(J))))1500,1520,1500
 1500 IF(ABSF(DX(J))-ABSF(DELMIN(J)))1520,1520,1510
 1510 NGATE=0
 1520 DX(J)=DX(J)/RATIO
 IF(NGATE)1530,1530,1600
 1530 IF(NTRACE)1570,1570,1540
 1540 WRITE OUTPUT TAPE KW,1550,(DX(J),J=1,NV)
 1550 FORMAT(* STEP SIZES REDUCED TO    */,
C5X,5E12.5,/,5X,5E12.5)
 1570 GO TO 380
 1600 CHISQ=CHIOLD
 IF(NTRACE)1630,1610,1610
 1610 PRINT1620,NF
 1620 FORMAT(//,I5,*  FUNCTION OPERATIONS*)
 1630 CONTINUE
 1640 IF(IABS(MATRIX-100)-50)1650,1650,2160
 1650 IF(NACTIV-NV)2160,1660,2160
* COMPUTE THE STANDARD ERRORS AND THE CORRELATIONS.
 1660 FAC=RATIO**(MATRIX-100)
 DO 1680 I=1,NV
 DX(I)=ABSF(FAC*DX(I))
 XSAVE(I)=X(I)
 JVARY=0
 DO 1670 J=1,2
 X(I)=XSAVE(I)+DX(I)
 CALL FUNK
 NF=NF+1
 JVARY = I
 SECOND(1,J)=CHISQ
 1670 DX(I)=-DX(I)
 X(I)=XSAVE(I)
 1680 ERR(I,I)=(SECOND(1,1)-2.0*CHIOLD+SECOND(1,2))/DX(I)**2
 DO 1710 I=2,NV
```

```
      IM=I-1
      DO 1710 J=1,IM
      DO 1700 K=1,2
      X(I)=XSAVE(I)+DX(I)
      JVARY=0
      DO 1690 L =1,2
      X(J)=XSAVE(J)+DX(J)
      CALL FUNK
      NF=NF+1
      JVARY=J
      SECOND(K,L)=CHISQ
      X(J)=XSAVE(J)
 1690 DX(J)=-DX(J)
      X(I)=XSAVE(I)
 1700 DX(I)=-DX(I)
      ERR(I,J)=0.25*(SECOND(1,1)-SECOND(1,2)-SECOND(2,1)
     C+SECOND(2,2))/ABSF(DX(I)*DX(J))
 1710 ERR(J,I)=ERR(I,J)
      IF(NTRACE)1770,1720,1770
 1720 WRITE OUTPUT TAPE KW,1730
 1730 FORMAT(*  SIZ OF INC USED BELOW*)
      WRITE OUTPUT TAPE KW,1740,(DX(J),J=1,NV)
 1740 FORMAT(5X,5E12.5,/,5X,5E12.5)
      WRITE OUTPUT TAPE KW,1750
 1750 FORMAT(///*  MATX OF 2ND PART DER*)
      DO 1760 I=1,NV
 1760 WRITE OUTPUT TAPE KW,1740,(ERR(I,J),J=1,I)
 1770 DO 1780 I=1,NV
      DO 1780 J=1,I
      IF(ERR(I,J))1780,1790,1780
 1780 CONTINUE
      GO TO 1810
 1790 WRITE OUTPUT TAPE KW,1800
 1800 FORMAT(/* MATX ↑ HAS = OR> 0,MAKE MATX LARGER FOR OK TEST*)
*     INVERT THE MATRIX USING SYMINV2(COMM. OF THE ACM 6,PAGE 67).
 1810 DET=1.0
      DETLOG=0.
      DO 1820 J=1,NV
 1820 SALVO(J)=1.
      DO 1970 I=1,NV
      BIGAJJ=0.
      DO 1850J=1,NV
      IF(SALVO(J))1830,1850,1830
 1830 IF(ABSF(ERR(J,J))-BIGAJJ)1850,1850,1840
 1840 BIGAJJ=ABSF(ERR(J,J))
      K=J
 1850 CONTINUE
      IF(BIGAJJ)1870,1860,1870
 1860 DET=0.0
      GO TO 1930
 1870 SALVO(K)=0.
```

```
 DET=DET*ERR(K,K)
 DETLOG=DETLOG+LOGF(ABSF(ERR(K,K)))/2.303
 TRIAL(K)=1.0/ERR(K,K)
 ERR(K,K)=0.0
 XSAVE(K)=1.
 M=K-1
 IF(M)1910,1910,1330
1330 DO 1900 J=1,M
 XSAVE(J)=ERR(K,J)
 TRIAL(J)=ERR(K,J)*TRIAL(K)
 IF (SALVO(J))1360,1900,1890
1890 TRIAL(J)=-TRIAL(J)
1900 ERR(K,J)=0.0
1910 M=K+1
 IF(M-NV)1920,1920,1960
1920 DO 1950 J=M,NV
 XSAVE(J)=ERR(J,K)
 IF(SALVO(J))1360,1930,1940
1930 XSAVE(J)=-XSAVE(J)
1940 TRIAL(J)=-ERR(J,K)*TRIAL(K)
1950 ERR(J,K)=0.0
1960 DO 1970 J=1,NV
 DO 1970 K=J,NV
1970 ERR(K,J)=ERR(K,J)+XSAVE(J)*TRIAL(K)
 IF(DET)2000,1980,2020
1980 WRITE OUTPUT TAPE KW,1990
1990 FORMAT(*ERR MATRIX IS SING-TRY INCREASE*)
 GO TO 2150
2000 PRINT2010
2010 FORMAT(* ERR MATX NEG DEC MATX*)
2020 IF(NTRACE)2050,2030,2030
2030 WRITE OUTPUT TAPE KW,2040,DET,DETLOG
2040 FORMAT(/* DET OF ↑ MATX*E12.5,* LOG10(DET)  *E12.5)
2050 DO 2090 I=1,NV
 DO 2060 J=1,I
 ERR(I,J)=ERR(I,J)*2.0
2060 ERR(J,I)=ERR(I,J)
 IF(ERR(I,I))2070,2070,2090
2070 PRINT 2080,ERR(I,I)
2080 FORMAT(* - OR 0 MEAN SQ ERR ENC* E15.8,*DEC MATX*)
2090 XSAVE(I)=SIGNF(SQRTF(ABSF(ERR(I,I))),ERR(I,I))
 IF(NTRACE) 2160,2100,2100
2100 PRINT 2110
2110 FORMAT(/* ST ERR.*)
 PRINT 1740,(XSAVE(J),J=1,NV)
 PRINT 2120
2120 FORMAT(/* LOW TRI OF CORR MATX*)
 DO 2140 I=2,NV
 IM = I - 1
 DO 2130 J=1,IM
2130 TRIAL(J)=ERR(I,J)/ABSF(XSAVE(I)*XSAVE(J))
```

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```
2140 WRITE OUTPUT TAPE KW,1740,(TRIAL(J),J=1,IM)
2150 WRITE OUTPUT TAPE KW,1620,NF
2160 CONTINUE
2190 JVARY=0
     CALL FUNK
     IF (NTRACE)2230,2200,2200
2200 WRITE OUTPUT TAPE KW,2210,(X(J),J=1,NV)
2210 FORMAT (//* FINAL VALUE OF X(I) */4E16.9,/3E16.9)
     WRITE OUTPUT TAPE KW,2220,CHISQ
2220 FORMAT(//* FINAL VALUE OF CHISQ = *,E15.8)
2230 RETURN
     END
```

Appendix S

COMPUTER PROGRAM WHICH ASSIGNS CSs ALONE, USs ALONE AND PAIRINGS TO INTERVALS AND TIME PERIODS RESPECTIVELY

```
1 PROGRAM INT
7 DIMENSION INAME(7)
8 DIMENSION NCS(200),NUS(200),INT(200),INTU(200)
9 READ (60,11),INAME
10 READ,NC,NU,NUMPAIR
11 FORMAT(4X,7A8)
15 READ,(NCS(I),I=1,NC),(NUS(I),I=1,NU)
20 DO 40 I=1,NC
24 A=NCS(I)
25 Q=(NCS(I)/20)
26 T=A/20.
27 IF(T .GT. Q+.5)34,30
30 INT(I)=(NCS(I)/20)+1
32 GOTO 40
34 INT(I)=(NCS(I)/20)+2
40 CONTINUE
45 DO 46 I=1,NU
46 INTU(I)=(NUS(I)/20)+1
47 WRITE (61,48),INAME
48 FORMAT(1X,///,*TAPE    *,7A8)
50 PRINT 52,NC,NU,NUMPAIR
52 FORMAT(1X,/,*CS =*,I3,8X,*                 US =*,I3,5X,*PAIRINGS =*,I4)
53 IF(NC-NU)54,70,65
54 PRINT 55,(NCS(I),NUS(I),I=1,NC)
55 FORMAT(I5,19X,I5)
56 PRINT 57,(NUS(I),I=NC+1,NU)
57 FORMAT(24X,I5)
60 GOTO 90
65 PRINT 66,(NCS(I),NUS(I),I=1,NU)
66 FORMAT(I5,19X,I5)
67 PRINT 68,(NCS(I),I=1+NU,NC)
68 FORMAT(I5)
69 GOTO 90
70 PRINT 66,(NCS(I),NUS(I),I=1,NC)
90 END
100 ENDPROG
```